SUBLITTORAL ECOLOGY OF THE KELP BEDS OFF DEL MONTE BEACH, MONTEREY, CALIFORNIA

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THESIS

SUBLITTORAL ECOLOGY OF THE KELP BEDS
OFF DEL MONTE BEACH, MONTEREY, CALIFORNIA

by

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Off Del Monte Beach, Monterey, California

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ABSTRACT

Macroscopic organisms collected by SCUBA divers throughout a large portion of the kelp beds at Del Monte Beach, Monterey, California, were identified and a list of species present was compiled. More than 160 such species were found to exist. Collection methods and techniques utilized by divers were documented. Numerous underwater photographs were taken.

A population census and mapping survey was made by divers of the benthic flora and fauna existing within two permanently marked bottom areas, one of which is to be eventually isolated from the open sea by erection of a breakwater. The areas were found to be of generally similar biological population but of markedly different species distribution and relative abundance.

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The author wishes to express his appreciation to Dr. E. C. Haderlie whose assistance, inspiration and patience was invaluable throughout; to Mr. Jack Mellor who contributed so much time and effort in my behalf and without whose technical assistance this investigation would have fallen far short of its goals; to Dr. Donald P. Abbott of Hopkins Marine Station who assisted in the identification of numerous species; to Mr. Anthony Weaver also of Hopkins for precious advice and generous loan of equipment; and particularly to my friends Dick Anderson, Harry Ball, Rich Belser, George Bollow, Greg Booth, Bob Delgado, Tom Fisher, Larry Gardiner, Fred Howell, Jack Mellor, and John Peterson who dove with me and without whose time and effort the study could never have been conducted.

Needless to say I am more than grateful to my wife, Carol, and our children, Julie and Scott, who provided much needed moral support and who put up with my continual absence from home.

I. INTRODUCTION

A. GENERAL

A long-standing proposal for the addition on two breakwater structures to the harbor at Monterey, California, appears to be nearing approval. Final project funding should be completed in the near future and work is expected to begin within two years.

In order to assess the ecological effects of these wave barriers an overall study of the area is being conducted by students and faculty members of the Naval Postgraduate School under the direction of Dr. Eugene C. Haderlie of the Department of Oceanography. The purpose of the Monterey Breakwater Study is to establish ecological base lines by which future changes can be measured [Haderlie, 1971].

A small portion of the overall study was performed by the author and is the subject of this thesis. The task was first to learn how to identify *in situ* the macroscopic organisms existing on the bottom in the kelp beds off Del Monte Beach and second to map and count the benthic plants and animals living within two carefully selected and permanently marked stations on the shale substrate. It was hoped that this could be accomplished without disturbing the stations in any way so that they could be revisited and restudied following the completion of breakwater construction. In pursuit of this objective a total of 56 SCUBA dives were made.

Since many of the methods commonly utilized in underwater biological sampling and data taking are still in the developmental stage, particular

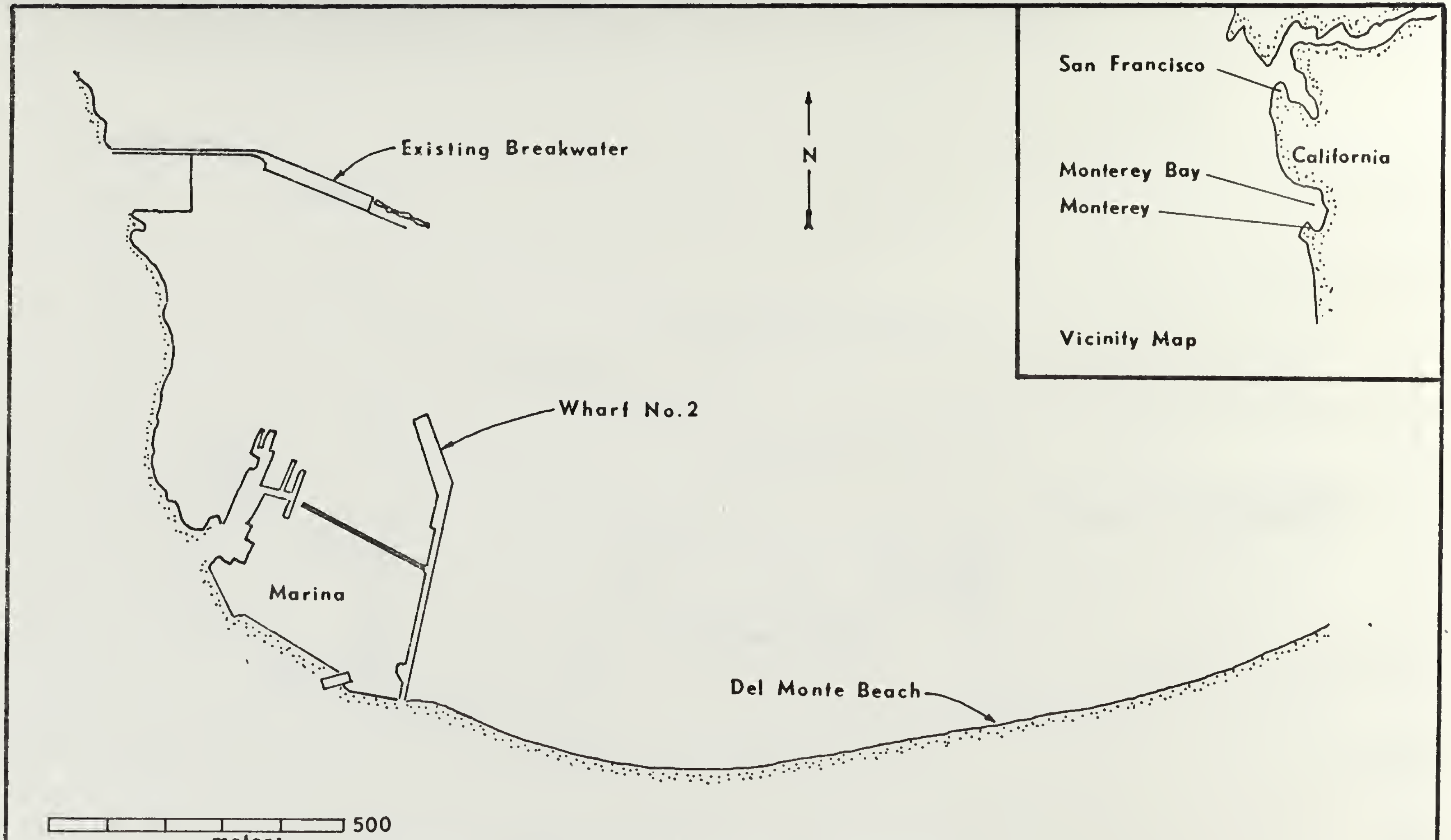


Figure 1. Present Harbor Area
Monterey, California

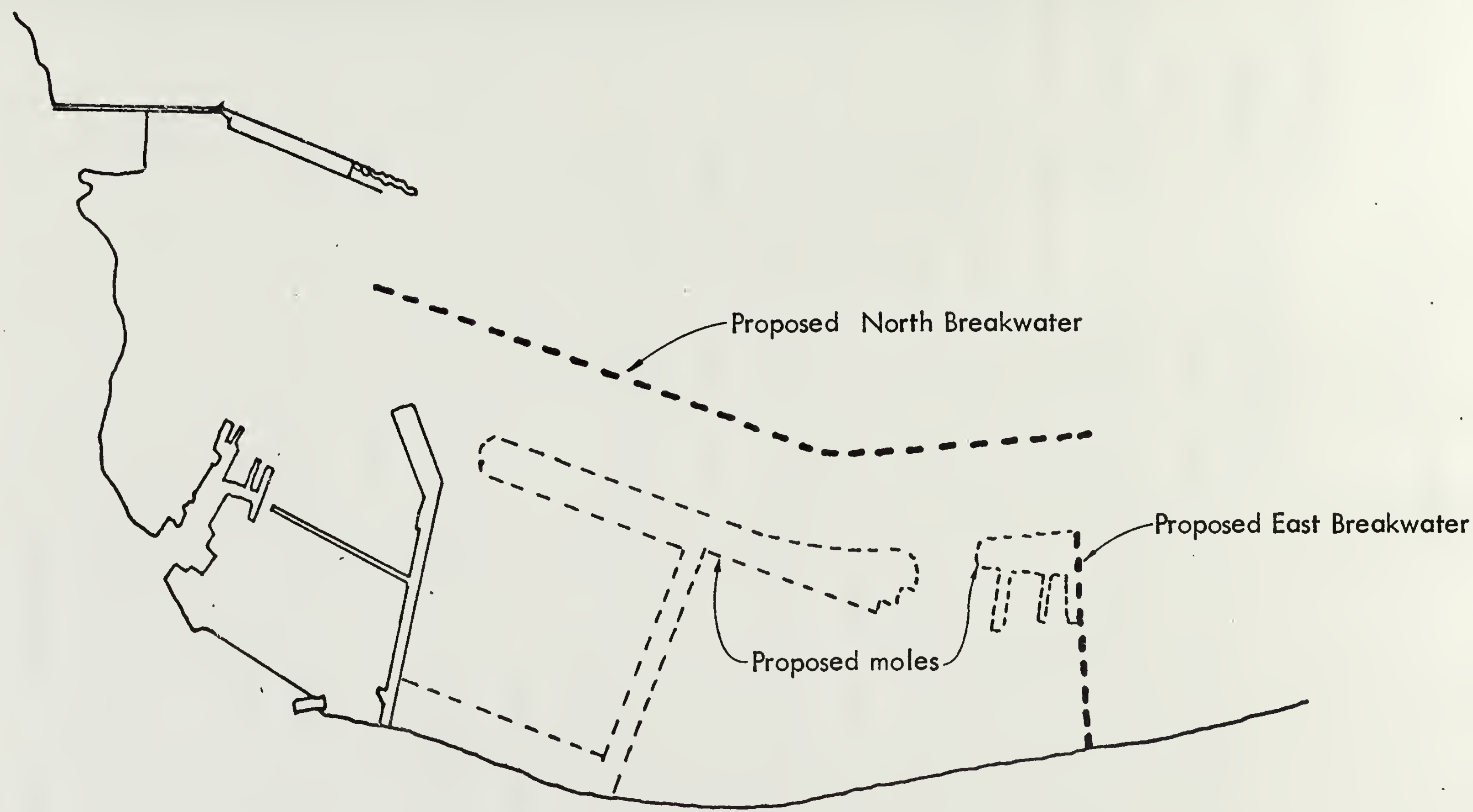


Figure 2. Proposed breakwater and mole structures

attention has been devoted to the documentation of those methods both new and old which could prove valuable to future investigators, especially those whose research funds are limited.

B. BACKGROUND

1. Breakwater Construction Plan

Figure 1 depicts Monterey Harbor as it exists today. The breakwater, a permeable granite block structure completed by the Army Corps of Engineers in 1934 adequately serves to protect the inner harbor from waves arriving from the north but the problem of water surge due to wave refraction is still present [Haderlie, 1971]. Municipal Wharf No. 2 built in 1926 provides some wave protection for boats moored in the existing marina. These factors coupled with the need for additional pier space for research vessels and a larger marina to accomodate the increased number of pleasure craft requires additional breakwater construction. The resulting plan, developed by the city of Monterey and drawn up by the Corps of Engineers is illustrated in Figure 2 which was scaled down from a Corps project chart. As can be seen in the figure, the proposal calls for the erection of two additional breakwater units, one to the north which will, in effect, form an extension of the existing structure and another to the east which will run out from the shore to essentially seal off the harbor area. Construction is to be phased over several years with the breakwater units to be completed first. These, like the existing one, are to be of granite rock construction and though permeable, will provide adequate

wave damping to protect the future 1,700 boat marina. The solid earth-and-rock moles depicted in Figure 2 will eventually provide hotel and restaurant sites as well as parking space. These however, will probably not be completed for several years.

2. The Monterey Breakwater Study

In order to measure the changes that will occur once the planned breakwater units are completed, the ecological nature of the area as it exists today must first be determined and documented. Such is the objective of the Monterey Breakwater Study currently being conducted by the Naval Postgraduate School and of which this work is a small part.

The heart of the study, initiated in January, 1971, consists of a set of four transect lines encompassing 15 stations which are being monitored on a continual basis. These transects, depicted in Figure 3, were selected to include each type of bottom substrate found in the area with water depths covering a range of from two to fifteen meters. By using a triangulation system based on accurately plotted navigation aids located on the beach front, all stations can be easily located at any time to within a few feet. The method of operation is depicted in Figure 4. Near each station bottom samples are being taken by a Smith MacIntyre benthic grab for use in analysis of the infaunal assemblage. Sediment samples are also being collected for grain size analysis. Parallel to transect lines, dredges and balloon trawls are being utilized to collect benthic organisms from soft-bottom areas. Vertical plankton hauls are also being made periodically. Much of the study area is covered by a large bed of

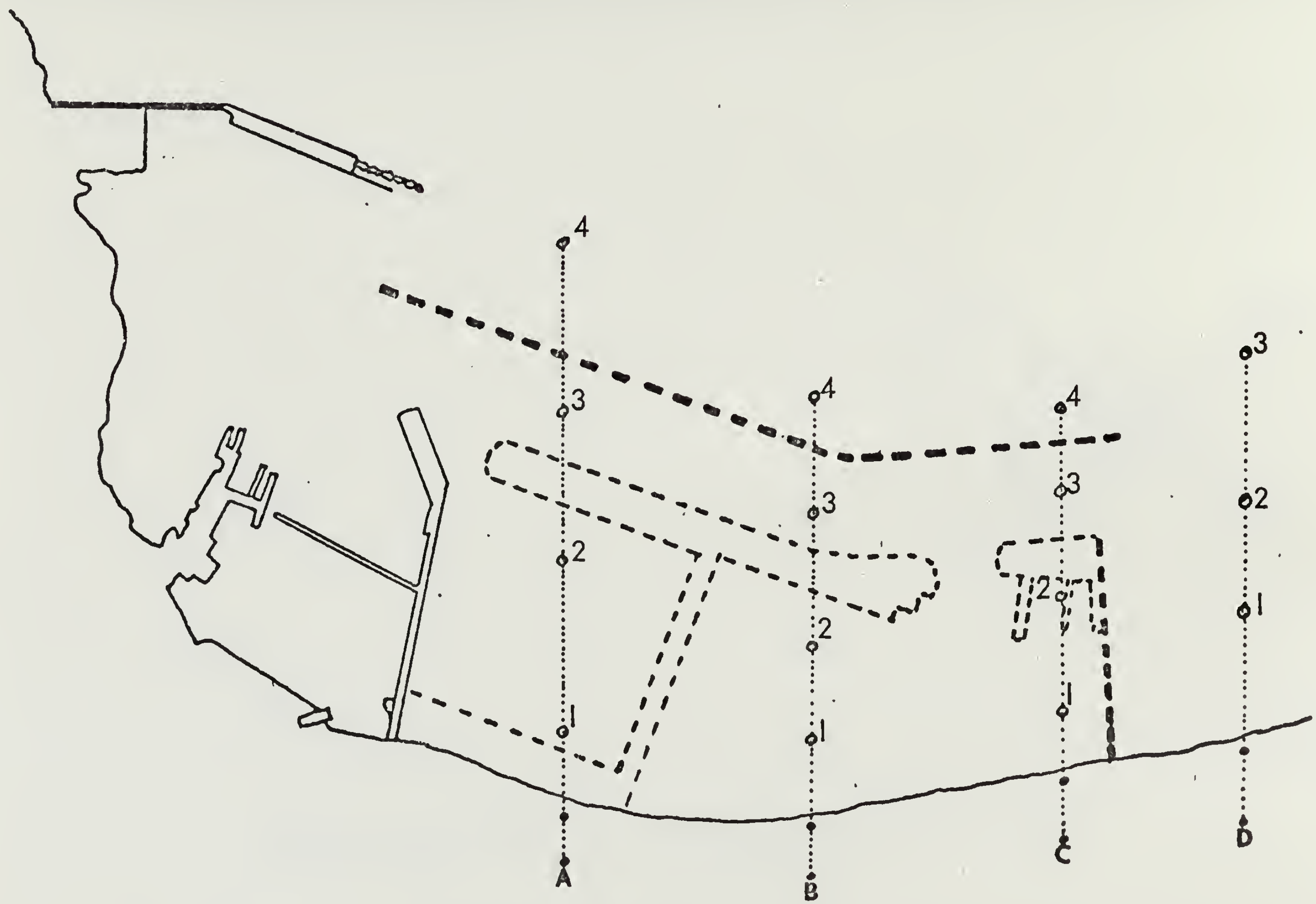


Figure 3. Location of transect lines

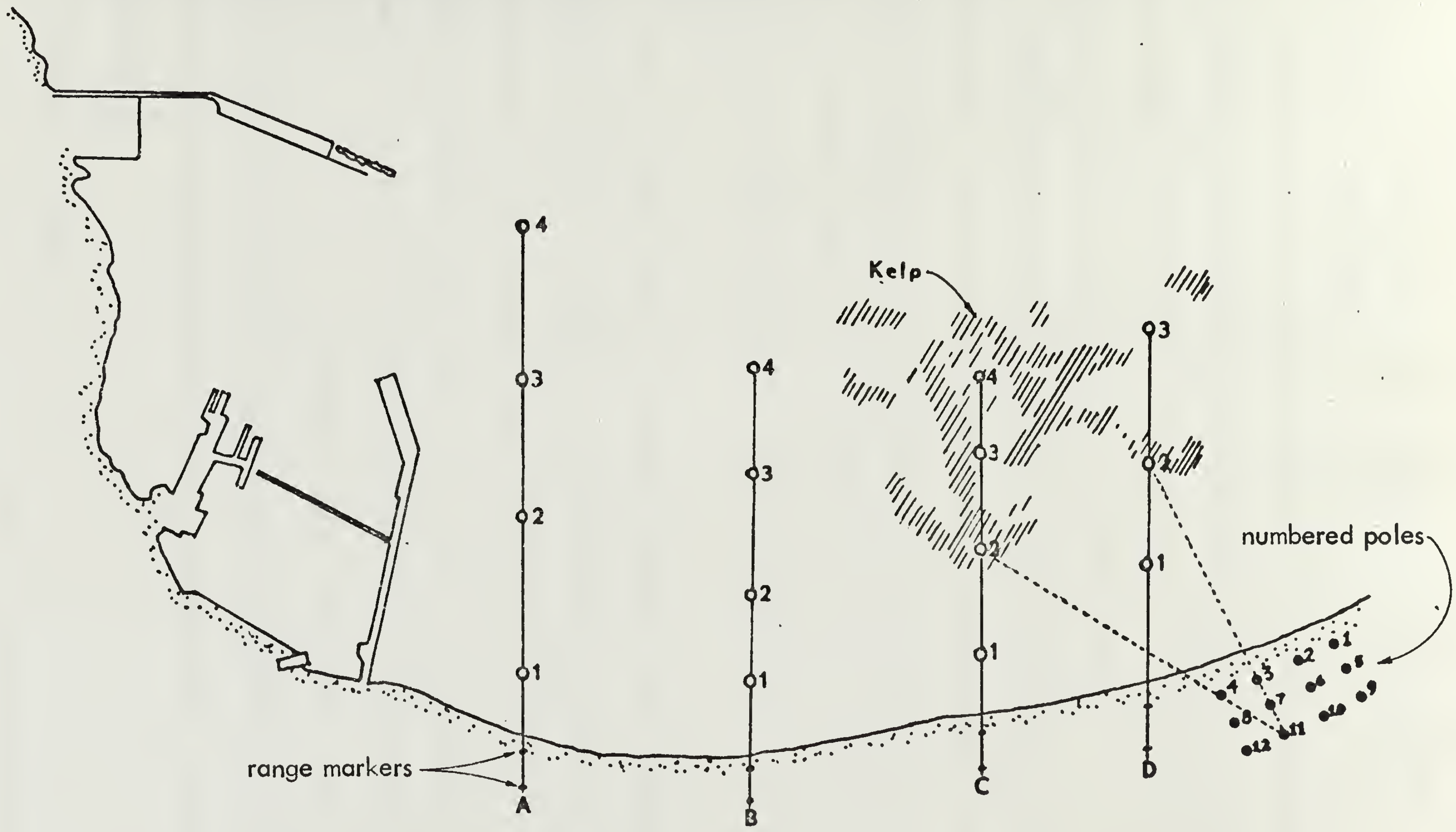


Figure 4. Triangulation system used in transect station location.
Location of Del Monte Beach kelp beds is also shown.

kelp (Figure 4) which grows from a shale substrate. Two of the shale bottom stations were studied by the author and are discussed at length in later sections of this paper.

As can be seen in Figure 3, transect "D" is located outside of the area to be enclosed by the proposed breakwater structures and thus should be little affected by their presence. This transect will provide an additional reference by which to measure later ecological changes.

Additional study input data includes tide, temperature, and salinity measurements. These are continually being monitored using equipment installed on Wharf No. 2. Several years of back records of tide, temperature, and wave heights are also available and a new wave recording transducer has recently been installed a short distance to the east of Station C2.

A considerable amount of ecological work has been performed on the pilings of Wharf No. 2 during the past few years by students of the Naval Postgraduate School and these unpublished data combined with extensive studies by Haderlie [1968, 1969, 1970] of the local fouling and boring organisms will supplement the data gathered during the Monterey Breakwater Study itself. It is thus expected that prior to the start of harbor development operations fairly extensive and reasonable accurate ecological base lines will have been established by which future changes can be measured and analyzed.

3. Previous Studies

Studies somewhat similar to the Monterey Breakwater Study have been conducted at a number of other locations along the California coast

but in almost every case the issue of concern was the construction of an ocean sewage outfall. A search of the pertinent literature failed to reveal any other example of a pre-breakwater ecological study. Papers by Turner, Ebert and Given [1965, 1966, 1968] did however, provide information on underwater biostudy techniques and methods of data presentation which proved useful in the preparation of this report.

II. NATURE OF THE PROBLEM

Although the faunal assemblage associated with the holdfasts of the giant kelp *Macrocystis pyrifera* in the vicinity of Monterey have been investigated by Andrews [1945], the benthic life that inhabits the intervening substrate in the beds of this plant is not well documented. McLean [1962] studied the benthic ecology of a granite substrate in beds of the bulb kelp *Nereocystis luetkeana* near Carmel, California. Presumably, that of like substrate in the *Macrocystis* beds of the Monterey-Pacific Grove region is generally similar, though some significant differences are certain to exist due to the differing wave regimes. The nature of benthic life in the *Macrocystis* beds off Del Monte Beach (Figure 4) where the substrate is of Miocene Monterey siliceous shale, has not been well established. Little is known regarding the relative abundance and distribution of the numerous genera known to exist there. In this thesis some light is shed on these areas where knowledge is lacking and part of the data required to accomplish the Monterey Breakwater Study is supplied.

The specific locations where detailed mapping and counting of macroscopic benthic organisms took place were Transect Stations C2 and D2 (Figures 3 and 4) which will be described later. The term "macroscopic" is here used to denote those species of flora and fauna which can be observed and studied by a SCUBA-equipped diver with reasonable ease under conditions of moderately clear water.

Before such a survey could be conducted it was of course necessary for the author to develop an ability to recognize underwater the various species of plants and animals which inhabited the study areas. This required gaining a knowledge of special identification features which in many cases are quite different from those commonly used in the laboratory. Since one of the objectives was to map and count the biota in undisturbed stations it was also necessary to be able to recognize each species by only those parts of its sturcture displayed at the time of observation. For example, boring clams of the family Pholadidae which are normally identified by an examination of their shells, had to be recognized *in situ* by studying their siphons, the only body parts which could be seen by a diver without chopping open the shale burrows.

In order to acquire the special knowledge required it was necessary to study the living animals both *in situ* and in laboratory aquaria. Specimens were collected throughout a large portion of the kelp beds without disturbing the eventual survey sites at Transect Stations C2 and D2. Methods of collection, identification and documentation are discussed in Section III. The collected specimens were kept alive in laboratory aquaria for as long as possible during which time they were identified and carefully studied. Particular attention was devoted to those features which would render *in situ* identification possible using, at most, a hand lens for assistance.

III. PRELIMINARY WORK

A. COLLECTION OF SPECIMENS

1. General

Most of the dives made during this work were made directly from Del Monte Beach. Fortunately the N.P.S. Biological Laboratory is conveniently located near the base of Transect D just a short distance from the water's edge. Thus, collected living organisms reached laboratory aquaria with only a brief period of exposure to open air. Most of the collecting took place in the region between Transect Stations C2 and D2. Buddy divers were trained to assist and thus added effectiveness to the work.

2. Methods and Techniques

The various techniques utilized in the collection of organisms is discussed in a fairly detailed manner because the shale substrate involved is quite unlike the rock, mud, or sand bottoms prevalent in most areas. It is inhabited by a vast population of boring, nestling, and burrowing organisms which are not easily collected intact. Many of the non-burrowing genera also present special collection problems which bear elaboration.

In general, divers utilized large nylon mesh collecting bags. The more rugged specimens were placed directly in the bags. Delicate ones such as sponges and nudibranchs were stored in large-mouthed plastic jars. Details of collecting which may prove useful to future investigators are presented in paragraphs which follow.

a. Porifera

The majority of kelp bed sponges were collected by hand or with the assistance of a diver's knife. Encrusting varieties were taken by hammer and chisel, collecting both the colony and the shale to which it was attached. Taking the colony intact was important for two reasons; first, to prolong aquarium life and second, to avoid damage to basal spicules which in some cases proved important in identification. It should be added that most sponges studies did not survive very long regardless of care taken in collection.

b. Coelenterata

With the exception of certain burrowing anemonies, members of this group were collected with relative ease. All of the hydroid species and several of the smaller anemonies, particularly _Metridium exilis_ and _Corynactis californica_ were taken by chopping off chunks of shale. The larger anemonies, mostly various species of _Tealia_, were carefully shaved off the substrate with a knife. The relative softness of the shale rendered this method possible without damage to the animal.

The small burrowing forms, tentatively identified as _Edwardsiella california_ and _Diadumene leucolena_, were often found dwelling in sand-filled crevices and holes (particularly abandoned pholad burrows) with the bases of their columns attached to the underlying shale. A "slurp gun" proved to be of great assistance in collecting these organisms. The sand surrounding an animal was sucked into the gun until the whole individual could be seen. It was then a simple matter to remove it by knife. The

advantage of this technique, in addition to the obvious benefit of working with an entirely exposed animal, was that water clarity could be maintained. Attempting to collect these anemonies by digging inevitably resulted in loss of visibility due to stirred up sediment.

c. Annelida

The polychaetes presented no major problems. Hammer and chisel were used to collect such species as Cirriformia sp. and Dodecaceria fistulicola while soft tube dwellers such as Diopatra ornata and Phyllochaetopterus prolifica were taken by hand.

d. Sipunculida

All species were chopped out of the shale with hammer and chisel.

e. Pelecypoda

Nearly all forms found in the kelp beds are borers or nestlers and are the most difficult to collect undamaged. These also were taken using hammer and chisel. In collecting the larger pholads such as Chaceia ovoidea which may bore eighteen or more inches into the shale, an attempt was made to locate individuals growing horizontally with siphons protruding from the side of a ledge. Much less chopping is required in this case as can be seen in Figure 5 which depicts a cross-sectional view of the substrate. (See also Figures 79 - 81.)

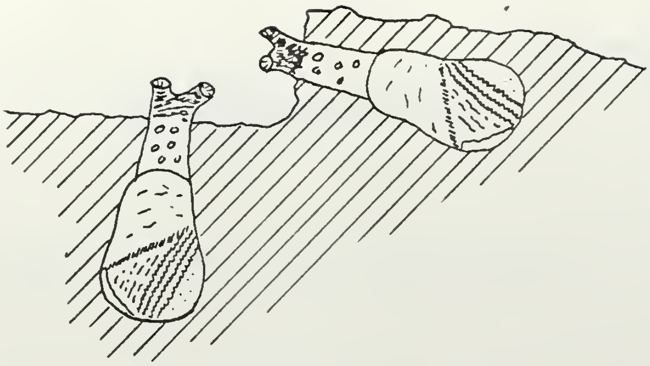


Figure 5. Shale cross-section showing boring pholad clams [Chaceia ovoidea]

Even so, the relatively fragile shells of the borers are easily damaged if chopping is not performed with care.

f. Tunicata

Solitary forms were easily taken by hand but encrusting varieties required hammer and chisel in the same manner as did encrusting sponges. Nearly all species are quite delicate and must be protected in jars after collection. Few survive more than a day or two in aquaria and thus require immediate study. Exceptions are the more rugged varieties such as Styela montereyensis, S. gibbsii, Pyura haustor and Boltenia villosa.

g. Vertebrata

Small demersal fishes, mostly flatfish (Order Heterosomata) and sculpins (Family Cottidae), were captured utilizing a short length of three-inch diameter clear plastic coring tube open at one end and sealed at the other with plastic screen as shown in Figure 6.

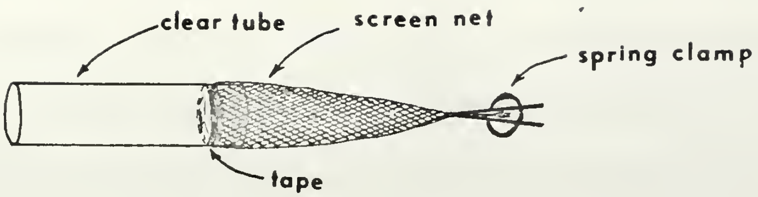


Figure 6. Demersal fish-catching device

The tapered end of the screen netting was not sewed shut but rather sealed off by a spring clamp as shown. The open end of the tube was simply placed over the fish forcing it to swim up the tube and into the net. The net end was then inserted into a nylon mesh collecting bag and the spring clip removed, releasing the fish. This method worked better than conventional small hand nets which the fish were able to see and evade.

A "slurp gun" was also used to collect some of the smaller flatfish and sculpins but was particularly effective in capturing the burrow-dwelling rockfish Neoclinus uninotatus (Photographs, Figures 96, 99) The tube-net method also worked well in taking this fish though two divers were required, one to hold the tube over the burrow and the other to drive a nail or spike through the shale into the burrow beneath the fish which could only escape by swimming up the tube.

B. LABORATORY IDENTIFICATION

Specimens collected during dives were kept alive in laboratory aquaria during the identification and study phase. Most macroscopic organisms existing in the kelp beds are also found intertidally and thus could be

identified using either Light's [1964] Intertidal Invertebrates of the Central California Coast or Smith's [1944] Marine Algae of the Monterey Peninsula. Additional information on intertidal organisms was gleened from a number of sources which are listed in the Bibliography. Invaluable assistance on tunicate and anemone identification was provided personally by Dr. D. P. Abbott of Hopkins Marine Station. Dr. E. C. Haderlie of the Naval Postgraduate School assisted throughout the course of the study in all phases of identification work.

C. RECOGNITION CARD FILE AND SPECIMEN LIBRARY

Once an organism had been identified, its *in situ* recognition characteristics were annotated on file cards. Sketches were also made and in a few cases, particularly with algae, small samples of the organisms themselves were taped directly to the cards. Specimens of most species were preserved for later study. These preserved samples along with the recognition card file are presently stored at the N.P.S. Biological Laboratory.

IV. AREAS OF STUDY

A. SELECTION AND LOCATION

When the preliminary work of species identification and study was about half completed and a good working knowledge of the bottom areas in the vicinity of Stations C2 and D2 had been achieved, sites for the actual benthic survey work were chosen. In selecting these an attempt was made to include as wide a range of species as possible within a workable size area while still maintaining close proximity to the nominal station locations. That is to say, the location of Stations C2 and D2 had previously been established along their respective transect lines and not until a considerable number of dives had been made was it determined that the actual geographical locations of these areas did not precisely coincide with those of optimum study characteristics. Thus the areas considered in this report are actually a slight distance away from their positions as depicted in Figure 4. Figure 7 illustrates the precise locations of these areas with respect to the official transect stations and their geographical orientation. During the study itself the stations were marked on the surface to facilitate rapid location by divers swimming from shore.

As stated above, area selection was not based on random quadrat methods commonly used in ecological studies [Turner, et al, 1964, 1965]. They were specifically chosen so as to include a diverse assemblage of

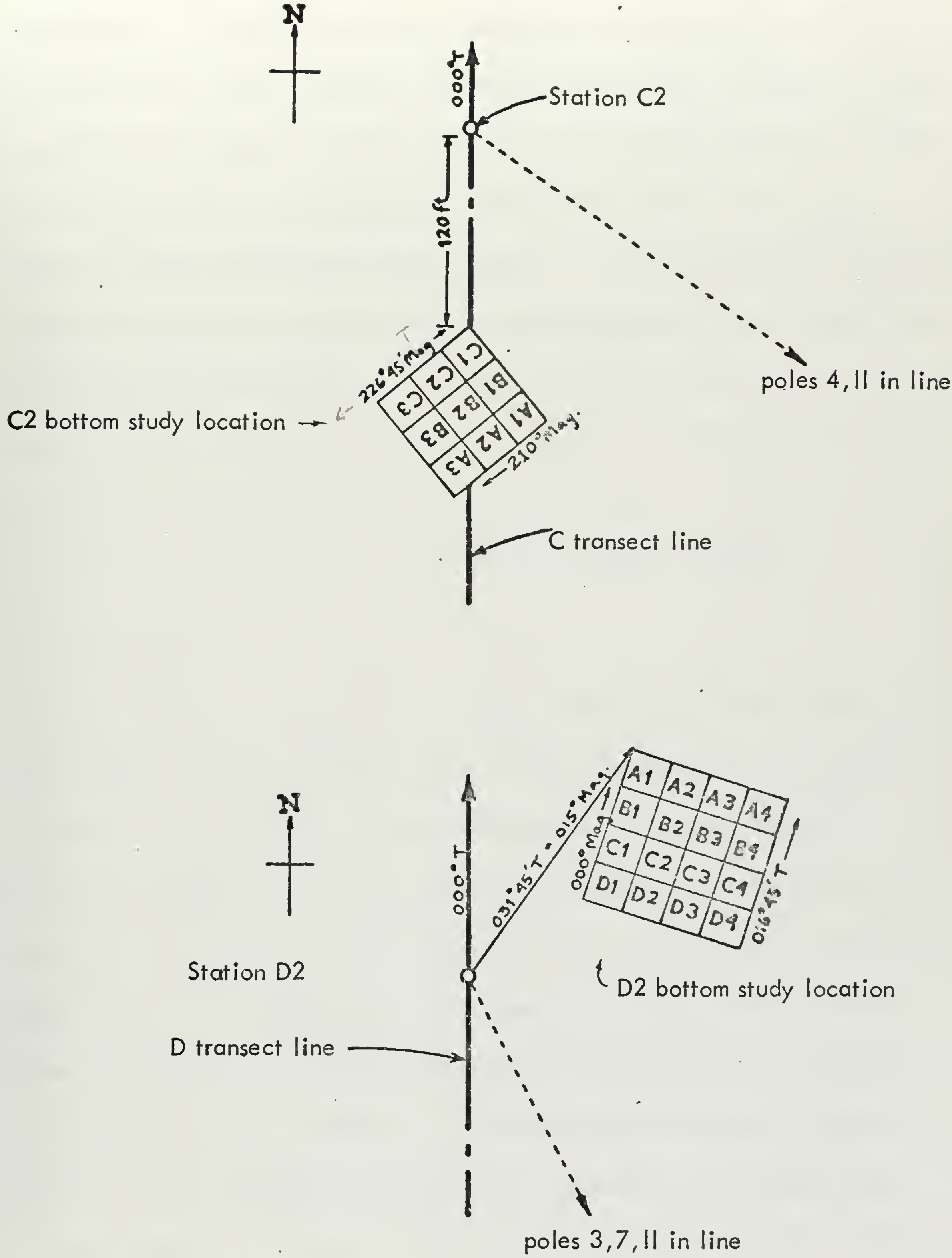


Figure 7. Exact positions of benthic study areas. Geographical orientation and subarea designations are shown.

benthic organisms in an area which could be permanently marked for later revisitation. In order to achieve a comparable sampling of the biota by random means a large number of small quadrats would be required and the feasibility of restudy lost. Even so, the areas at C2 and D2 by no means include all macroscopic species found in the kelp beds. Thus, in addition to the data taken at these stations, a discussion of the presence and distribution of numerous other species collected throughout the beds will be found in section VIII. A master list of all macroscopic species observed is contained in Appendix E. It might be added that the presence of some of the rarer kelp bed species would probably never have been discovered if purely random study methods had been utilized.

B. DESCRIPTION

The study site at Station C2 is a three-meter square area of relatively level shale substrate marked only by minor step-like erosion features. The area is located near the inner (shoreward) boundary of the kelp bed in 30 feet of water. Thus it is frequently subjected to a considerable amount of bottom surge produced by long period swell arriving from the open sea. This is especially true during the winter and early spring when a large amount of particulate matter is maintained in suspension. During such periods underwater visibility may be reduced to a matter of inches. This suspended material, which appears to be primarily algal detritus, settles to the bottom along with larger wave-torn plant fragments during periods of calm water to provide an ample supply of food for

benthic herbivores. Evidence of this settling is most obvious on pockets of sand which acquire a thin brown coat of deposited material.

While the faunal assemblage is fairly large, the most significant invertebrates inhabiting C2 are members of the boring mollusc family Pholadidae which literally riddle the shale with their large, deep burrows. A large number of annelid and sipunculid worms are also present. The benthic algal community in the kelp beds is not diverse. In C2 several species of coralline algae constitute approximately 70% of the total number of macroscopic plants present. There are three sizeable Macrocystis pyrifera holdfasts found within this area.

The area at D2 is considerably different both in topography and faunal distribution. This is a larger square, four meters on a side, and although no kelp holdfasts are included it does incorporate a three-foot high reef-like shelf of densely populated shale as well as a large sandy mound inhabited by a vast population of the tube dwelling annelid Diopatra ornata. Although the water depth here is 37 feet, somewhat greater than at C2, the amount of bottom surge is generally stronger. This is explained by the fact that D2 is located approximately 300 meters to the northeast of C2 giving it a wider "viewing angle" to the open ocean and rendering it less subject to the refraction of swell from the west and southwest. The surrounding bottom is more heavily pocketed with sand than that at C2 and the kelp canopy less extensive. However, periods of high wave activity distribute ample quantities of detrital material from adjacent areas. This source combined with the nutrients brought in by upwelling

is sufficient to support the diverse benthic community which exists. The elevated shale reef which runs through D2 is subject to somewhat amplified water motion due to the Venturi-like effect produced by wave surge flow. This feature seems to have a profound effect on the distribution of certain species along the vertical seaward face of the reef and is discussed further in section VIII.

C. STATION MARKING PROCEDURES

Once the study areas had been selected they were permanently marked on the bottom to permit long term relocation and temporarily marked on the surface to aid divers during the period of this study.

1. Bottom Marking

To permanently mark the study area substrate in such a manner as to render relocation possible after a period of up to two years, a method devised by Anthony Weaver of Hopkins Marine Station, Pacific Grove, California was utilized. Using a hand-held pneumatic hammer, adapted by Weaver for use with a conventional SCUBA tank, to which a standard 3/4" masonry star drill had been fitted, holes were drilled in the shale substrate at each corner of the two prospective study areas. A 3/4" outside diameter lag shield was pounded into each hole and into these were screwed 1/2" x 6" cadmium coated lag bolts leaving approximately two inches protruding from the substrate. In several cases the pholad-weakened shale cracked under the stress and a new hole had to be drilled. The completed stations were then lined off with 3/8" yellow polypropylene

line which proved to be highly visible even under fairly turbid water conditions. (See Figure 71)

2. Surface Marking

To facilitate area location by divers during the course of the study, a method developed by scientists at Scripps Institution of Oceanography [Fager et al, 1966] was modified to fit local water conditions. This consisted of attaching one end of an air-filled pliable plastic tube, the interior ends of which had been rubber cemented, rolled and tape sealed, to one of the corner bolts. The tubes were made long enough to allow the free end to reach the surface with several feet to spare at high tide. Unless it is of very sturdy construction and anchored by an extremely heavy weight, a conventional buoy used in a kelp bed will be torn loose during periods of high wave activity when tangled mats of broken kelp wash against it. The advantage of the plastic tubing is that it permits the kelp to slide over without snagging and thus does not require a large anchor. It is also less conspicuous to curious boaters. The floating portion of the tubes used in this study had been previously labeled with a black marking pen to indicate that research was being conducted. During the course of the study only one tube had to be replaced after having apparently been cut off by a boater or possibly by an outboard motor.

The method proved so successful that it bears some additonal discussion. While Fager [1966] used short lengths of garden hose which did not reach the surface, he was working in shallow, relatively clear water. Since this study was conducted in moderately deep and often

turbid water it was necessary that the marker reach the surface for it to be easily located. With no brightly colored garden hose readily available, the author experimented with bright orange pliable tubing designed for use in repairing lawn chairs. This was pressure filled from a SCUBA tank and sealed at each end. The method worked well and cost very little. However, when a period of a year or more is involved a garden hose or other similar heavy tubing would probably prove longer lasting.

V. DATA TAKING EQUIPMENT AND PROCEDURES

Once the majority of macroscopic species of benthic flora and fauna had been learned, population counting and mapping was begun.

A. EQUIPMENT

The basic tools utilized in the data taking process consisted of a clipboard to hold the recording slate, a master list of species, a small hand lens, and a pair of calibrated crossbars by which one-meter squares were marked off.

1. Clipboard

While aluminum clipboards are available, for short term studies they offer no great advantage over an appropriately modified inexpensive fiberboard model. The latter type was used in this study and proved quite satisfactory. The only modification made was the attachment of a combination spring clip and pencil holder at the bottom. These are available in most stationery stores. An ordinary No. 1 wooden pencil was attached to the clipboard by a light nylon line.

2. Recording Slate

A number of materials have been used for underwater work, mostly plastic sheets of one form or another. In this study, .04 in. thick bakelite cut to 8-1/2" x 11" plates was evaluated and found to be superior to other materials tested. Bakelite, normally used for making signs, name-tags, etc., is quite durable. Its surface is highly responsive

to lead pencil yet is not easily smudged. Thus plates may be towel-dried after a dive without fear of marring the data. When necessary the plates can be erased and reused without altering the surface qualities. Unfortunately the only bakelite immediately available at the time survey work began was of a light gray color and although it served the purpose quite well, white would have provided better contrast.

The vinylite material recommended by Fager [1966] was not used so no comparison is offered.

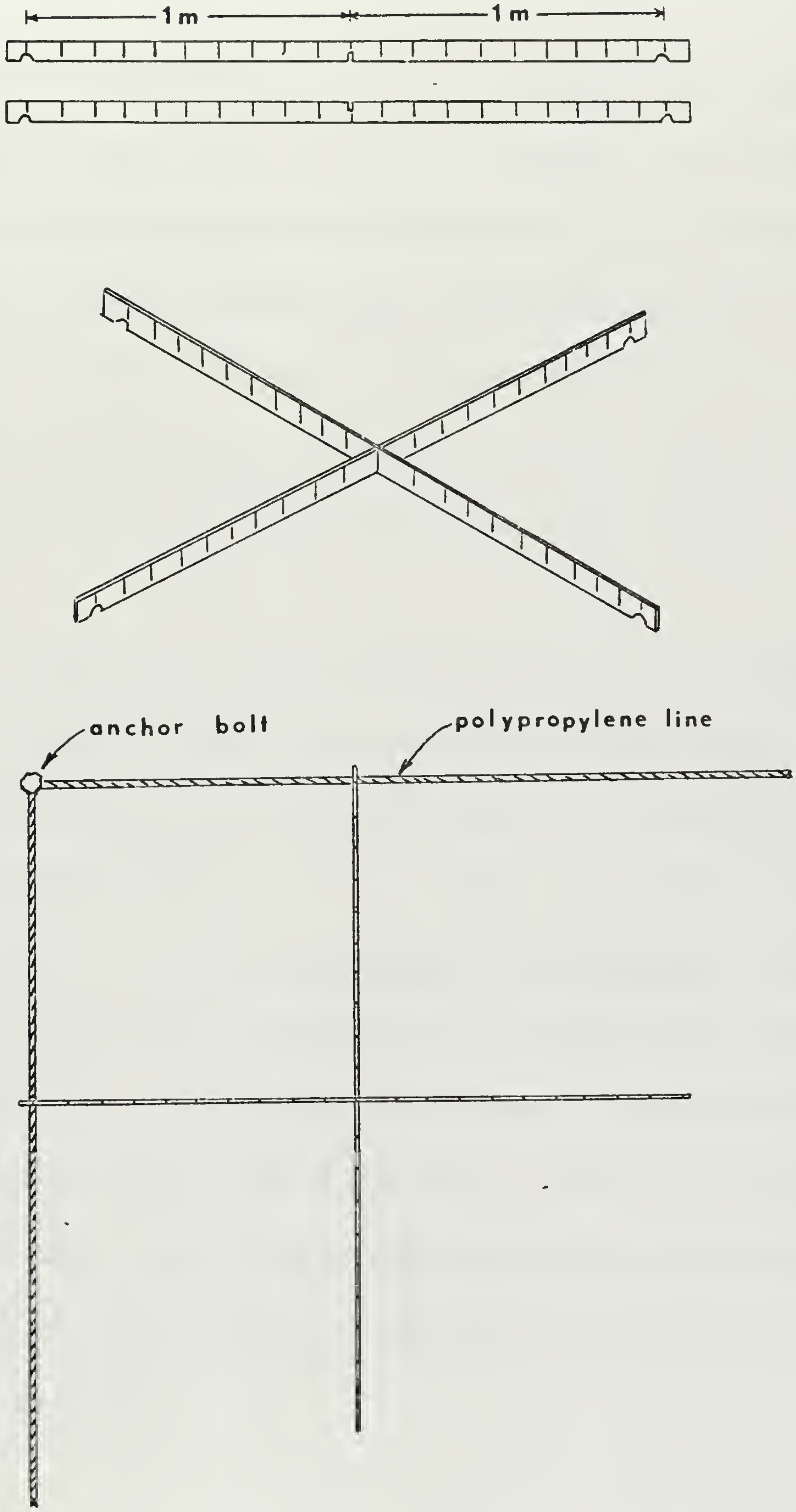
3. List of Species

A master list of all macroscopic species collected during preliminary dives and which might be encountered in the study areas was printed on a 12" x 16" sheet of ridged white plastic using a fine-pointed, permanent, waterproof marking pen. The sheet was taped to a piece of fiberboard to prevent accidental cracking and a lead weight attached to overcome the problems of wave surge. In this way the list could be placed on the bottom out of the diver's way without having to be hand tended.

4. Area Subdividers

As previously described the study areas were outlined with polypropylene line. In order to subdivide these into one-meter squares to facilitate mapping and counting, a pair of aluminum crossbars were used. These bars and their method of operation are illustrated in Figure 8. They were marked and labled at ten-centimeter intervals using the permanent marking pen.

Figure 8. Aluminum crossbars used to subdivide study areas into one-meter-squares



B. PROCEDURES

For each one-meter square mapped and counted, one side of a recording plate was used. Each plate had been previously inscribed with an area outline scaled down to a 6" x 6" format and tick-marked every 3/5" to represent ten-centimeter divisions and thus correspond to the aluminum crossbar markings. This square was used for mapping. An additional 3" x 6" area was inscribed below the area outline for use in recording population data and general observations. As mapping progressed the crossbars were simply moved about as necessary and left on the bottom between dives. By using the 6" x 9" format on 8-1/2" x 11" plates the data could be traced directly onto smooth paper, labled, and incorporated into the report.

To avoid the necessity of writing out the lengthy scientific name of each organism mapped, a simple letter-number code was assigned to each species and recorded on the master species list for ready reference.

To assist in differentiating species of nearly similar characteristics such as the corraline alga genera Bossiella and Calliarthron a small hand lens was used. Spot checks of temperature were made using centigrade thermometers left on the bottom at each study area. Water clarity was simply estimated by divers. Due to the numerous possible sources of suspended particulate matter such as wave surge, plankton, and sewage (from the nearby Monterey outfall), no particular significance can be attached to the estimates.

VI. PHOTOGRAPHY

A. GENERAL

All underwater photographs were taken using the Nikonos 35mm and Rolleimarin 2-1/4 in. cameras. The Nikonos was used to take subarea photographs (Appendix B) and close-ups of individual organisms (Appendix D) while the Rolleimarin was utilized solely for taking composite photographs of various benthic species (Appendix D).

A considerable amount of photographic experimentation was carried out during the course of the study in an effort to arrive at the optimum film and camera settings for use in the often murky water of the kelp beds. Most of the work was done in black-and-white due to publication requirements, however color characteristics of most of the organisms photographed have been described, either in the photograph captions or in Biological Observations (section VIII).

Underwater illumination for both cameras was provided by a Subsea Mark 150 battery powered strobe which could be set to 50, 100, or 150 watt-seconds (w.s.).

B. NIKONOS

As mentioned above, the Nikonos was used for both distant (area photographs at 2.75 feet) and close-up work.

1. Area Photographs

All area photographs were taken at a distance of 2.75 feet, the minimum setting possible on the Nikonos without close-up attachments.

In taking these photographs no attempt was made to entirely cover each square meter of the study areas. The purpose was rather to provide the reader with some idea of the bottom topography and the general nature of the benthic flora and fauna to be found within each meter-square.

In order to achieve the desired 2.75 foot distance a small weight was dangled from the camera on a measured length of monofilament line. This worked well especially when bottom surge prevented the diver from achieving a firm stance. In such a case the diver swam into position above the area and let himself sink slowly until the weight just touched bottom at which time the picture was taken.

For the purpose of labeling the areas small pieces of white plastic were inscribed with the area letter-number code using a black "grease" pencil. A clip-on lead weight was used to prevent the label tags from being carried away by bottom surge.

Best results were achieved using 400 A.S.A. black-and-white Tri-X film with the strobe set at 100 w.s., the shutter at 60 and f/22 stop.

2. Close-up Photographs

Close up work was performed using either a one-to-one, two-to-one, or three-to-one extension tube. In some cases the buddy diver assisted by handling the strobe to achieve optimum illumination of the subject. Film type and camera/stobe settings were the same as for area photographs except that an f/16 stop was used.

C. ROLLEIMARIN

This camera was used to take composite shots of several species at a time. An extension tube designed by Mr. Jack Mellor of the N.P.S. Oceanography Department worked well for these shots which were all taken at 11-1/2". It consists simply of a thin metal probe extending in front of the camera from a semi-circular clamp-on base fitted to the outer housing of the camera. (The tip of the probe is visible in the composite photographs in Appendix D). With this camera 125 A.S.A. black-and-white Plus-X film was used with a strobe setting of 100 or 150 w.s. depending on water clarity. The shutter was set at 125 and the focal length at 3 feet (close-up lenses in place).

VII. PRESENTATION OF DATA

A. GENERAL

The actual data collected at stations C2 and D2 consists of: (1) separate maps of each meter-square subarea showing principal topographic features and major fixed and semi-fixed organisms, (2) photographs of meter-square subareas, and (3) population census data for each area presented in tabular form. Each of these sets of data is incorporated in separate Appendix to this thesis (A, B, and C respectively). Explanatory notes precede each Appendix.

B. ACCURACY

This type of study is necessarily subject to a great many sources of error.

1. Errors in Species Identification

These come into play in two ways; first by incorrect initial laboratory identification resulting in error carried throughout the study and second, by occasional incorrect identification *in situ* during data taking. The latter is likely to occur when attempting to differentiate similar organisms under conditions of poor visibility and/or when insufficient recognition characteristics are exposed. While hopefully not significant, errors of this type were undoubtedly made during this study.

2. Errors Due to Lack of Visibility

Unfortunately many of the dives made during this study were necessarily performed during periods of high wave activity in the late

winter months and during the spring and summer plankton blooms when water clarity was far from ideal. Errors in mapping in counting resulting from poor visibility probably constitute the major source of inaccuracy in this report. Undoubtedly population counts made during such conditions are on the low side. It should be added that during periods of significant wave activity many creatures which might otherwise be observed seek shelter under rocks and ledges, again resulting in an erroneous count.

3. Errors in Estimation

Lack of time precluded making exact counts of some of the more numerous species such as Corynactis californica so only estimates could be made.

4. Lack of Detail

In order to arrive at a reasonably good overall picture of benthic ecology it was necessary to study areas of considerable size. Time limitations simply precluded inclusion of numerous small species which might be considered macroscopic.

VIII. GENERAL BIOLOGICAL OBSERVATIONS

A. GENERAL

In this section the abundance, distribution and *in situ* recognition characteristics of the various macroscopic species that inhabit the Del Monte kelp beds are discussed. Though particular attention is devoted to benthic organisms, general observations concerning a number of infaunal and nectonic species are made. While a large portion of the overall kelp bed area was at least cursorily examined during the course of the study, most of the collecting was performed in the region between the Transect stations of concern, C2 and D2. Therefore many of the comments made in the paragraphs which follow are based primarily on observations made in this area and may not all be completely accurate on the large scale.

B. DISTRIBUTION AND RECOGNITION CHARACTERISTICS

Only those species of which reasonably accurate diving and laboratory based observations can be made are listed here. A master list of all macroscopic species found in the kelp beds is contained in Appendix E. Underwater recognition characteristics are described for species which may be difficult or impossible to recognize *in situ* using conventional identification keys such as Light's *Intertidal Invertebrates of the Central California Coast* [1964]. Some of the characteristics listed, however, are essentially identical to those found in Light [1964], Ricketts, Calvin

and Hedgpeth [1968] and other references listed in the Bibliography. Organisms are described as they occur in the Del Monte kelp beds. They may exhibit somewhat different characteristics elsewhere, particularly in intertidal areas. Figure references following some descriptions refer to photographs in Appendix D.

PORIFERS (Sponges):

Acarnus erithacus .... Common but not abundant. Some colonies quite large. Found on horizontal surfaces. (Figure 65)

Craniella sp. .... Scarce. Observed only on horizontal surfaces. Small yellow-tan spheres not easily noticed.

Hymenamphiastra cyanocrypta .. Thin, encrusting, cobalt blue variety. Rare.

Leucosolenia eleanor .... Abundant. Primarily observed clinging to various small alga and to the hydroid *Abietinaria* spp. (Figures 66, 100)

Polymastia pachymastia .... Rare. Yellow finger-like structures protrude from common base. Base may be covered with detritus causing fingers to appear as individuals and possibly be mistaken for the vase-like sponge, *Rhabdodermella nuttingi*. (Figure 67)

Rhabdodermella nuttingi .... Fairly scarce. Easily identified.

Unidentified Sponges:

No. 1 .... Vase-like variety much like Rhabdodermella except much smaller and more elongate. Uncommon. Not easily observed.

No. 2 .... Thin, fleshy encrusting variety. Bright orange in color. Oscules on closely spaced tubercles which retract when disturbed. Seems to thrive best on vertical surfaces. Abundant when present. Distribution patchy (Figures 68, 99)

No. 3 .... A salmon pink variety with the consistency of rubber. Surface covered with small peduncular projections shaped like minute mushrooms. Rare. (Figures 69)

No. 4 .... Thin encrusting reddish orange form occurring in patches. Often covered with silt rendering detection difficult. Common in some areas.

No. 5 .... Globose yellow variety found on horizontal surfaces. Fairly common though not abundant.

No. 6 .... Thick red form much like Acarnus erithacus but lacking raised oscules. Rare.

Other .... Numerous species not described. Identification of these sponges would make a fertile field for study.

COELENTERATA (Hydroids, Anemonies, etc.):

Hydrozoa:

Abietinaria spp. .... A fairly large hydroid abundant in some areas (D2), less common in others. Easily identified by shape and arrangement of hydrothecae. (Figure 90)

Aglaophenia spp. .... Probably more common than observations indicate. Infrequently observed.

Plumularia spp. .... Small and frail. Difficult to observe in turbid water. Common in all areas.

Anthozoa:

Anthopleura artemisia .... Common in most areas, particularly numerous on horizontal surfaces where shale is thinly coated with sediment. Semi-burrowing. Often difficult to distinguish from A. elegantissima since entire column rarely visible. Brightly colored (often red) tentacles and dark grey upper column are good indicators of this species.

Anthopleura elegantissima ..... Common though not aggregated as found intertidally and usually smaller. (Figure 101)

Balanophyllia elegans .... Common in all shale areas; nowhere abundant. Usually occurring in small groups of three to ten individuals. Easily distinguished from Corynactis californica by presence of calcareous skeleton which may be detected by lightly pressing animal with bare fingertip. Bright orange in color.

Cerianthus sp. ....Large, burrowing tube dweller quite rare in Del Monte beds.

Corynactis californica .... Small generally pink or red variety common in most shale areas, abundant in some. Easily recognized by capitate tentacles. (Figure 100)

Diadumene leucolena .... Small burrowing form common in areas where sand fills shale holes and crevices. Nowhere abundant. Distinguished from other burrowing forms by abundance of thin, nearly transparent tentacles. (Figure 98)

Metridium exilis .... Small orange anemone common in all shale areas. Occurs in abundance on some ledges and rarely on sandy mounds among Diopatra ornata tubes. Distinguished from Balanophyllia elegans by lack of skeleton; from Corynactis californica by the tapered, non-capitate tentacles; and from other kelp bed species by orange color. (Figures 74, 75, 79, 94)

Tealia coriacea .... Slightly smaller than T. lofotensis. Identified by green splotches on red column and lateral rows of tubercles (which the animal can retract at will leaving column smooth to the touch). Fairly common though nowhere numerous. (Figure 71)

Tealia crassicornis ....Very large form with smooth, deep scarlet column and whitish tentacles. Rare.

Teatlia lofotensis .... Large anemone with white-spotted red column. Scarce.

Unidentified anemones:

No. 1 .... Small burrowing variety with few (11-12) white tentacles which lie flat on sand in daisy-like pattern. Believed to be *Edwardsiella californica*. Common but not abundant in sandy areas and in sand-filled holes in shale. Attached to underlying substrate. Capable of great elongation. (Figures 70, 102)

No. 2 .... Small burrowing form similar to No. 1 but with 11-12 nearly transparent tentacles. Possibly same species. Common in same areas. (Figures 70, 81)

No. 3 .... A large form with crustose, laterally banded tubercles on column. Possibly an old *Tealia coriacea* or *T. lofotensis*. Rare.

ANNELIDA (Polychaete worms):

Cirriformia sp. .... Abundant in all shale areas. Recognized by numerous thin, red tentacles.(Figures 77, 99, 101)

Diopatra ornata .... Common in most areas. Abundant on scattered sandy mounds. Recognized by debris-encrusted hook-shaped tubes. Distinguished from *Thelepus*, sp. *in situ* by lack of long filamentous tentacles.(Figure 45)

Dodecaceria fistulicola .... Distribution patchy. Usually found in large brain-like clumps of fused tubes. Deep green

tentacles give tube mass mossy appearance. (Figures 74, 94, 98, 101)

Endistylia polymorpha ....Easily recognized "feather duster". Relatively scarce. (Figures 75, 76)

Phyllochaetopterus prolifica ....Commonly found individually or in small groups; rarely in tangled mass of long, thin, flexible tubes.

Sabellaria cementarium .... Rare except in holdfasts of Macrocystis. Sandy tubes difficult to see.

Salmacina sp. ....Scarce under ledges. Easily recognized by their masses of very thin, fragile white tubes from which the bright red animals protrude.

Serpula vermicularis ....Fairly common. Twisted white tubes usually found along ledges and in crevices. Recognized by white tube and funnel-shaped operculum. Not found in large colonies.

Thelepus sp. .... Scarce. Usually found among colony of Diopatra ornata. Recongized by very long filamentous tentacles.

Unidentified species .... Believed to be Myxicola sp. Rare. (Figure 73)

SIPUNCULOIDEA (sipunculid worms):

Dendrostomum dyscritum ....Numerous in all shale areas. Only light tan plume-like tentacles protude form substrate. (Figure 72)

Dendrostomum pyroides .... Common but not as abundant as *D. dyscritum*. Tentacles slightly more bushy with deep red inner branches. Introvert hooks occasionally visible.

Phascolosoma agassizii .... Numerous in all holes and crevices. Black-spotted introvert not easily seen.

ARTHROPODA:

Crustacea:

Cirripedia (Barnacles):

Balanus crenatus .... Abundant on most loose pieces of shale and nearly all ledges. Heaviest covering on vertical surfaces. Only small species present. (Figure 79)

Balanus nubilis .... Numerous but not abundant on ledges. Large, easily recognized.

Decapoda (crabs, etc.):

Cancer sp. .... Several species present. Juveniles scarce, adults rare.

Cryptolithodes sitchensis ...... The unmistakable umbrella crab, an Anomuran. Rare. (Figure 80)

Loxorhynchus crispatus .... Numerous medium-sized masking crabs in all areas. Recognized by decurved rostrum, hairy legs and pear shaped corapace which is always covered with living camouflage. Large adults common but not numerous. (Figure 78)

Loxorhynchus grandis .... Less common. Large adults rare.

Mimulus foliatus ....Common in most areas. Small, not easily spotted. (Figure 102)

Pugettia producta .... Occasionally seen on substrate. Common among fronds of *Macrocystis*.

Pugettia richii ....Same as *Mimulus foliatus*.

MOLLUSCA:

Amphineura (chitons):

Cryptochiton stelleri .... Common in all areas but not numerous. Large adults rare.

Mopalia ciliata ....Rare or at least not easily seen. Usually silt covered. Distinguished from *M. muscosa* by cleft girdle and presence of acute white spines at base of girdle hairs. This check requires use of hand lens.

Mopalia muscosa .... Rare and not easily seen.

Placiphorella velata ....Common in all shale areas. Nowhere numerous. Can be spotted by animal's habit of raising head flap while feeding. Recognized by nearly circular outline and elongated head flap.

Tonicella lineata .... Scarce on tops of ledges. Usually found on purple patches of the encrusting algae *Lithothamnion* sp.

Pelecypoda (clams, etc.):

Chaceia ovoidea ....Common in most shale areas numerous under large ledges. Easily recognized by very large

purple-tipped, united siphons which protrude several inches from shale. Lower part of siphon column white with brown chitinous warts which distinguish it from all other species. (Figures 79, 80)

Hiatella arctica .... Common in upper part of ledges. Distinguished from other borers by small, red, united siphons. Difficult to see. (Figure 101)

Hinnites multirugosus .... Scarce. Difficult to distinguish in situ from Pododesmus cepio. Upper (unattached) valve with numerous short, fluted spines not present in Pododesmus.

Kellia laperousii .... Small nestler scarce in ledges. Recognized by single visible siphon which is cylindrical, pure white and unadorned.

Lithophaga plumula .... Small chemical borer common in shale. Unusual flap-like siphons barely protrude from substrate. Very difficult to see.

Parapholas californica .... Large borer abundant in all horizontal shale substrate. Easily identified by cylinderical, flat-tipped united siphons which protrude little if at all from substrate.

Penitella sp. .... Small to medium size borer common in most shale. Primary species believed to be P. penita.

Penitella gabbi .... Larger form rare in sand-covered shale. Distinguished by longitudinal ribbing on interior surface of incurrent siphon. Siphons united. (Figures 83, 84)

Podcdesmus cepio .... Common on most shale surfaces. Nowhere numerous. Usually silt-covered and difficult to see.

Zirfaea pilsbryi .... Large borer rare in sand covered shale areas. Siphons much like Penitella gabbi but more massive; outer surface characterized by small wart-like bumps not present in P. gabbi . Burrow extremly deep. Difficult to capture undamaged.

Gastropoda (snails):

Astraea gibberosa ....Rare in all areas.

Calliostoma annulatum .... Scarce on fronds of Macrocystis. Distinguished by gold color and purple bands on whorls.

Calliostoma canaliculatum ..... Fairly common on Macrocystis fronds.

Calliostoma costatum .... Same as C. canaliculatum. (Figure 100)

Ceratostoma foliatum ....Scarce on sandy shale. Usually partially burried, difficult to spot. Identified by three large flange-like extensions of shell.

Crepidula adunca ....Slipper limpet common on shells of kelp snails.

Diodora aspera ....Scarce, not easily spotted.

Megatebennus bimaculatus ..... Rare in all areas.

Ocenebra sp. .... Common in most areas. Small. Not easily identified.

Pusula californiana .... Very rare snail. Shell small, blue with white ribs. One of the few cowry-shaped shells in the Monterey area.

Tegula brunnea .... Common on kelp fronds.

Tegula montereyi .... Same.

Unidentified snails: .... Many small forms numerous to abundant in sand and near kelp holdfasts. Common on shale. Difficult to see.

Opisthobranchia:

Tectibranchia:

Acteon punctocoelata .... Small tectibranch numerous on sandy shale. Easily identified by revolving bands of fine black-and-white stripes. (Figure 85)

Nudibranchia: (Sea slugs):

Aegires albopunctatus .... Small black-spotted white form common in most areas though not easily noticed. Nowhere numerous.

Aeolidia papillosa .... Extemely rare form with numerous white processes somewhat like those of *Hermissenda*. Body oval.

Ancula pacifica .... Small white and yellow variety. Rare.

Anisodoris nobilis .... Large black spotted "sea lemon" common on shale. Distinguished from Archidoris montereyensis by having spots between but not on, dorsal tubercles, six branchial plumes and brighter yellow color. Larger.

Archidoris montereyensis ...... Dusky yellow form less common on shale. Dark splotches on and between tubercles. Seven branchial plumes. (Figure 100)

Chioraera (Melibe) leonina .... Large translucent form periodically common on kelp fronds. Recognized by large oral hood and fleshy, nearly transparent body.

Dendronotus albus .... Beautiful semi-translucent, white form identified by yellow-tipped branching dorsal processes. Scarce on benthic alga. (Figure 86)

Diaulula sandiegensis .... Common to scarce on shale. Ring-like splotches on smooth white dorsum renders this species unmistakable.

Doriopsilla albopunctata (formerly Dendrodoris fulva) ...... Scarce form distinguished from Archidoris montereyensis by lack of dark spots and presence of white flecks on tips of dorsal papillae.

Flabellina iodinea .... Beautiful purple form with reddish orange dorsal processes. Rare in kelp beds.

Hermissenda crassicornis ......Common in all shale areas. Occasionally numerous. The most abundant nudibranch observed in the area. (Figure 100)

Laila cockerelli ....Small, not easily seen form rare in all areas.

Pleurobranchea californica ......Tectibranch with shell entirely buried in mantle. Semi-translucent; very difficult to see. Few observed.

Polycera atra .... Rare. Those found in Del Monte kelp beds fit Light's [1954] description rather than MacFarland's [1966].

Polycera quadrilineata..........Only one of these observed during entire period of study. Not easily seen.

ENTOPROCTA:

Barentsia gracilis ....Unbranched form rare on shale. Not easily observed.

BRYOZOA:

Membranipora membranacea .....White encrusting variety common on kelp fronds. Observed to nearly cover fronds on some plants in late August. (Figure 87)

Phidolopera pacifica ....Yellow-orange leafy form rare on ledges.

Thalamoporella californica ..... Articulated coral-like variety rare at bases of ledges. (Figure 88)

Unidentified species: .... Several species common on shale. Difficult to identify _in situ_. None described in this study.

ECHINODERMATA:

Asteroidea (starfish):

Dermasterias imbricata .... Scarce in all areas. Arms broad at base much like Patiria miniata. Usually mottled yellow and red. May be identified by lack of spines on aboral surface. Almost slimy to the touch. Leathery.

Evasterias troschelii .... Narrow-armed form scarce in all areas. Red in color. Distinguished from _Henricia leviuscula_ by having sizable spines scattered over aboral surface and from _Pisaster brevispinus_ by presence of pedicellaria clusters among spines that border tube foot groove.

Henricia leviuscula .... Fairly small form easily recognized by long narrow arms, red-orange color and minuteness of spines. Common in some areas, scarce in most.

Leptasterias sp. .... Small six-rayed form rare in all areas.

Patiria miniata .... Bat star. Common but nowhere numerous. (Figure 93)

Pisaster brevispinus .... Pinkish form numerous on ledges, common in all areas. Most abundant form in kelp beds. Can usually be identified _in situ_ by pink color, grouping of spines and fuzzy appearance.

Pisaster giganteus .... Large form common on ledges. Large spines ringed by naked skin identifies this species.

Pycnopodia helianthoides ...... The large, easily recognized multi-rayed star. Common but not numerous in most areas. Usually found along bases of ledges.

Ophiuroidea (Brittle stars):

Unidentified species: ....Brittle stars are abundant in shale burrows and in *Macrocystis* holdfasts. They seldom expose themselves and thus were not studied. Andrews' [1945] study lists holdfast species many of which likely dwell in the shale as well.

Echinoidea (urchins):

Strongylocentrotus purpuratus ...Small form fairly scarce in shale crevices. (Figure 98)

Holothuroidea (sea cucumbers):

Cucumaria piperata .... Common to numerous in shale crevices and vacant burrows. Difficult to spot underwater.

Eupentacta quinquesemita ...... Same as Cucumaria. (Figure 102)

Stichopus californicus .... Large, easily recognized form rare on shale.

CHORDATA

Ascidiacea (non-pelagic tunicates)

Amaroucium solidum .... Thick, slab-like, compound form scarce on large ledges where maximum surge develops. Usually

pinkish to orange. Color due to zooid pigmentation. (Figure 89)

Amaroucium sp. .... Thick, white form scarce to common on or near ledges. White in color. Believed to be _A. californicium_.

Boltenia villosa .... Individual form. Scarce, attached to shale or small benthic alga. Easily identified by spiny appearance, rounded shape.

Clavelina huntsmani .... Social form common to abundant on shale and near algal holdfasts (particularly those of _Dictyoneuropsis reticulata_). Easily recognized by teardrop shape of upper thorax, the outer layer of which is nearly transparent and through which may be seen the bright orange intestinal tract. (Figure 51, 99, 101)

Cnemidocarpa finmarkiensis .... Extremely rare individual form. Only specimen observed during study found in area C2-D2. Unmistakable. Pinkish with pearly luster. Apertures distinct. (Figure 89)

Cystodytes sp. .... Fairly scarce encrusting form. Semi-translucent. Pinkish to colorless. Firmer and thinner than _Amaroucium_. Usually with numerous small, white, disc-shaped spicules within test. (Small incision and hand lens required to identify _in situ_).

Family Didemnidae .... Fairly thin encrusting form. Translucent, pink. Cannot be distinguished _in situ_ from an

unspiculated form of Cystodytes. Rare in kelp beds. Little known of local varieties (Abbott, personal communication).

Eudistoma sp. .... Red compound form common to abundant on ledges and some horizontal surfaces. Characterized by closely packed, truncate lobes which bear numerous small protuberances on upper surface.

Eudistoma diaphanes .... Small, translucent, compound form characterized by knob-like shape. Common on most shale areas. (Figure 95)

Eudistoma molle .... Compound form common to scarce on horizontal surfaces. Easily identified by red spots (zooids) on opaque milk-white mound. (Figure 90)

Euherdmania claviformis ...... Social form scarce to common on ledges. Much like Pycnoclavella but much thinner, longer and more sand-encrusted. Nearly colorless.

Pycnoclavella stanleyi ...... Social form scarce on ledges. Recognized by many tiny flecks of bright orange on tips of thin, dark brown, closely packed, sand-encrusted tubes. (Figures 91, 92)

Pyura haustor .... Individual form common among small benthic alga in some areas, not found in others. Apertures bright red and borne on long, retractable tubes which may resemble clam siphons. In retraction, aperture closes to form cross-shaped seal. (Figure 93)

Styela gibbsii .... Small individual form common but not numerous in most shale areas. Test reddish, tough and wrinkled longitudinally. Apertures usually turned to one side and borne close to main body. (Figure 94)

Styela montereyensis .... Easily recognized individual form common in most areas; nowhere numerous.

Synoicum parfustis .... Compound form consisting of club-shaped lobes, red-orange at the tips and sand encrusted below. Does not seem to reach intertidal size in the kelp beds. Zooids generally less than 25 mm long. Patchy distribution. Nowhere abundant.

Trididemnum opacum .... Thin chalky-white encrusting form which may be mistaken for a sponge. Rare in kelp beds. (Figure 95)

Unidentified species .... Large solitary form extremely rare under ledges. Test is tough, covered with long, flexible, barbed, spine-like protrusions. Test white, spines tan. Attached to substrate by broad area basally. Apertures widely separated, undetectible when closed.

Vertebrata (Fish):

This study was primarily devoted to benthic plants and invertebrate animals. The only vertebrate enumerated in the population count (Appendix C) was the burrow-dwelling Neoclinus uninotatus. The following is, therefore, only a partial list of species observed during the course of the study.

Anarrhichthys ocellatus .... The Wolf-Eel. Scarce under ledges. (Figure 97)

Citharichthys sordidus .... The Pacific Sanddab, numerous particularly on sand pockets.

Damalichthys vacca .... The Pile Perch. Common but not numerous.

Heterostichus rostratus .... The brightly marked Kelpfish, fairly common.

Hexagrammos decagrammus .... The Greenling. Common but not numerous.

Hypsurus cargi .... Rainbow Perch. Common, beautifully colored.

Neoclinus uninotatus .... The Onespot Fringhead, a colorful jawfish found dwelling in crevices under rocks and in vacant pholad holes. Distinguished by the single black spot on the dorsal fin and the presence of long branched cirri on the head above the eyes. (Figures 96, 99)

Ophiodon elogatus ....The Lingcod. Only small fish were observed. Scarce.

Paralabrax clathratus .... Kelp Bass. Numerous.

Pheuronichthys decurrens ...... The Curlfin Turbot. Common to scarce.

Porichthys notatus ....The Midshipinan. Rare

Sebastodes chrysomelas .... The Black and Yellow Rockfish.

Other ....Numerous other species.

Several additional species of flatfish (order Heterosoma) and rockfish (Family Scorpaenidae) are present in large numbers. A few sculpin species (Family Cottidae) are also common.

ALGAE:

Rhodophyta:

Bossiella orbigniana ....Dichotomously branched coralline form numerous to abundant on horizontal shale surfaces. Recognized by frail structure and acutely pointed intergenicula. (Figures 80, 101, 102)

Calliarthron sp. .... Larger coralline form similarly distributed. Distinguished from Bossiella by presence of conceptacles on edges of segments as well as on flat faces. Many plants lack visible conceptacles and were simply classified under family Corallinaceae.

Callophyllis sp. .... Small palmately branched form distinctly red in color. Common in most shale areas.

Corallina chilensis .... Coralline form distributed in patches. Common where existing, otherwise scarce. Distinguished from Bossiella and Calliarthron by unwinged segments and from Corallina gracilis by decreasing length of branches away from base.

Plocamium coccineum .... Small, fine structured, distinctly red variety common on horizontal shale.

Lithophyllum .... Small to large purple encrusting patches common to numerous on shale. Believed to be principally _Lithothamnion califoricum_.

Lithothrix aspergillum .... A scarce coralline form recognized by cylinderically segmented straight, unbranched shoots.

Rhodymenia sp. .... Dark red form common to abundant on shale. Patchy distribution.

Unidentified species .... Thin, deep purple encrusting form on shale. Usually found with _Lithothamnion_. Believed to be _Peyssonnelia pacifica_. Fairly common but not abundant.

Phaeophyta:

Cystoseira osmundacea .... Common but nowhere numerous on shale. Most plants in kelp beds stunted or damaged, seldom found with pea pod-like floats.

Desmarestia herbacea .... Extremely rare but definitely present (Light [1962] indicates plant not found in kelp beds). Recognized by small bladlets on margins of main axis and branch fronds.

Disctyoneuropsis reticulata .....Large bladed form characterized by midribbed fronds which are laterally reticulated. Common on most shale areas.

Macrocystis pyrifera .... The giant kelp which dominates the beds.

Pterygophora californica .... A kelp variety rare on shale. Observed only in deeper areas near D2. Midstripe on terminal frond only.

2. Sea Otter Predation

Less than ten years ago McLean [1962] reported that no sea otters lived in Monterey Harbor and that urchins and abalones were abundant on the bottom off Mussel Point in Pacific Grove. It is now common knowledge that otters do range into the harbor area and have taken a severe toll on the urchin and abalone population of the area. Observations made during the course of this study indicate that the Del Monte kelp beds have also been heavily foraged by otters. Varying numbers were observed in the area at different times. No more than ten were observed at any one time and on most days fewer than four could be seen.

A 1966 study of the food habits of the Southern Sea otter (*Enhydra lutris nereis*) by Earl Ebert [1968] of the California Department of Fish and Game revealed that these animals appear to prefer abalones, urchins, and crabs but that when the supply of these is exhuasted, mussels, starfish, rock scallops, and chitons will also be eaten. Though no observations were made during this study of what otters were eating in the Del Monte kelp beds, divers found ample evidence to indicate that a once extensive abalone population had been annihiliated. Numerous shells of the Red Abalone (*Haliotis rufescens*) were observed littering the bottom yet not a single living animal was seen. In addition, no living specimens of the red urchin, *Strongylocentrotus franciscanus*, and very few of the smaller purple urchin, *S. purpuratus*, were observed. Though no evidence of their former abundance was found, there is every reason to believe that they once existed in great numbers since many were observed by McLean

[1962] in nearby areas and their association with *Macrocystis* was established by Dawson *et al* [1960].

It was also noted during this study that neither the rock scallop, *Hinnites multirugosus*, nor the abalone jingle, *Pododesmus cepio*, occur in great numbers and most of those that do exist are found in protected crevices. Those found in the open are generally quite difficult to see. Though the masking crab, *Loxorhynchus crispatus* and its larger relative, *L. grandis*, were frequently seen during dives very few of the otter-preferred *Cancer antennarius* [Ebert, 1968] were observed and those were usually small. No clues were found, however, to indicate the previous populations of these species and no mention of this was found in the literature. Starfish still exist in large numbers and apparently have not been bothered by the otters.

IX. CONCLUSIONS

Preliminary predictions of some of the ecological changes to be expected after breakwater completion were published by Haderlie [1971] . The most significant ones will likely result from the increased range in diurnal temperatures imposed by the loss of circulation within the enclosed area. A decrease in salinity due to entrapped fresh water runoff is also expected. Temperature and salinity sensitive plants and animals will likely prove unable to adapt to these environmental changes and some species may disappear entirely. More tolerant species may replace outgoing forms.

With regard to the kelp beds, loss of wave induced bottom surge will undoubtedly result in a high degree of silting. These fluctuating bottom currents will no longer be present to sweep clean the shale which in time will become covered with sediment. This prediction is based on diver observations of current benthic conditions in the existing inner harbor where a thick layer of silt covers the substrate. With the disappearance of holdfast space, the kelp itself as well as nearly every species of benthic flora will most certainly vanish within a short time and with them will go a host of invertebrate and fish species.

Another factor suggested by Haderlie [1971] will be the increased level of pollution brought in by the many commercial and pleasure craft slated for berthing in the proposed marina. Pollutants will no longer be

flushed to sea with the changing tides since the area will be almost entirely enclosed.

The loss in circulation will also greatly restrict the amount of upwelled nutrient-rich water that can enter the inner harbor thus denying plants and animals much of their food supply.

It can be safely stated that the addition of the proposed breakwater structures to Monterey Harbor will have a significant impact on the ecology of the area as it now exists and particularly in the kelp beds which are populated by a diverse and complicated floral and faunal assemblage.

APPENDIX A: SUBAREA MAPS

In this Appendix areas C2 and D2 are mapped by one-meter-square subareas each designated by a letter-number (row-column) code. See Figure 7 for geographical orientation of the subareas.

As previously mentioned organisms are represented by letter-number codes in the interest of saving time and space. These map symbols are listed with the associated species in Appendix B. Other information needed to interpret the drawings is included in the following list.

1. The letters "j" and "a" which follow some map symbols indicate "juvenile" and "adult" respectively. These are used only occasionally to provide reference marks and where not appearing, no inference as to animal size or age can be made.

2. Figures following a dash after map symbols indicate the numerical abundance of the particular organism at that location.

3. The exact positions of most organisms are indicated by small circles or caricatures. In some cases area coverage, particularly by plants, is indicated by larger closed curves.

4. Only fixed and semi-fixed organisms are plotted with the exception of a few chitons and the burrow-dwelling fish Neoclinus uninotatus. In some cases where large numbers of fixed organisms are present only a select few are plotted. This is usually indicated in the "Remarks" area under the map.

5. All maps are oriented as illustrated in Figure 7.

6. Due to complexity of biota and difficulty of observation the large undercut ledge in area D2 was not mapped. Photographs of this ledge do appear in Appendix B.

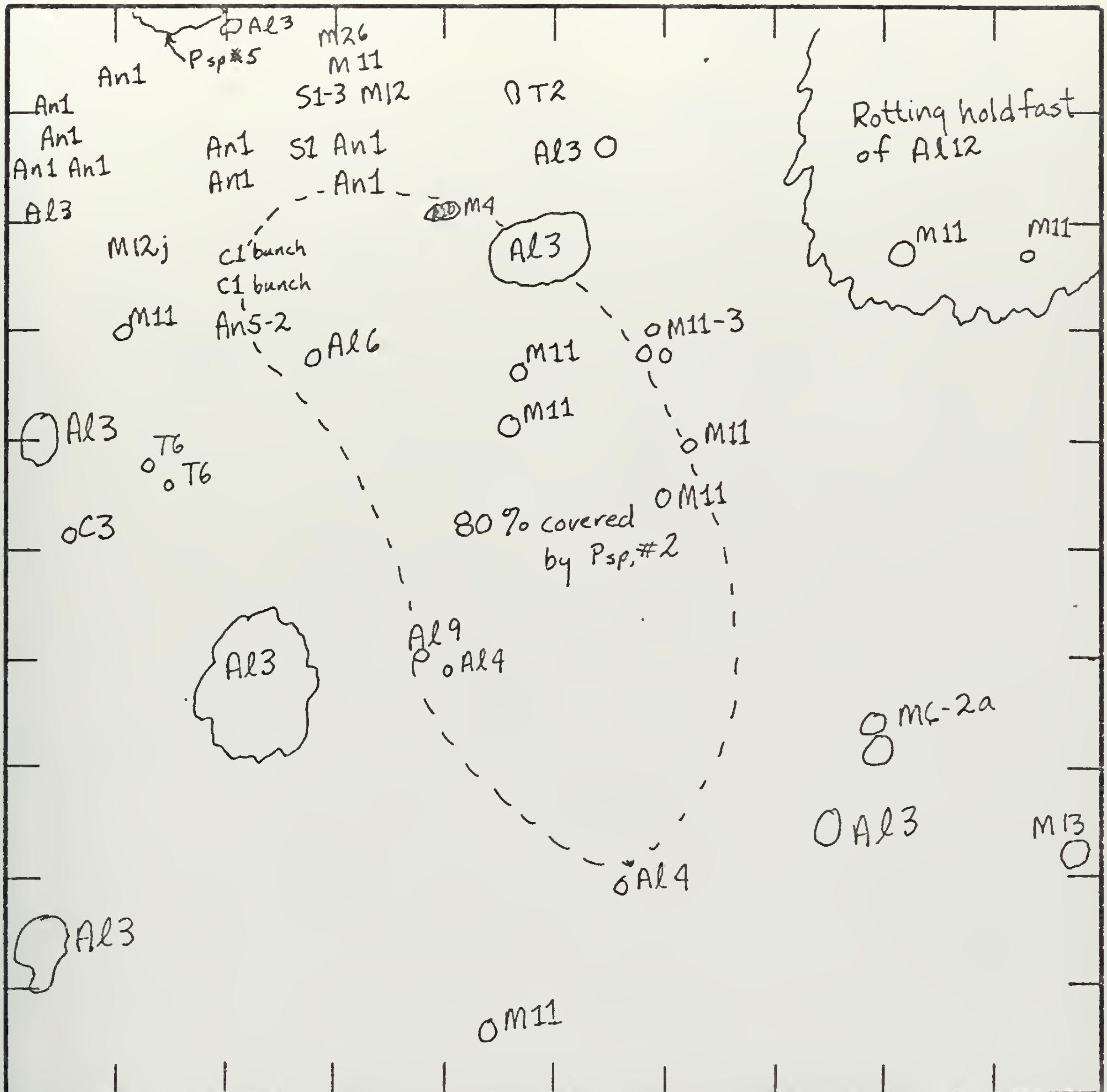


Figure 9. Subarea C2—A1

Remarks:

1. Only a few of the 97 Cirriformia sp. and 16 Dendrostomum sp. counted are plotted above.
2. Two Neoclinus uninotatus followed diver during mapping and counting of this area. They showed little fear and seemed quite curious.

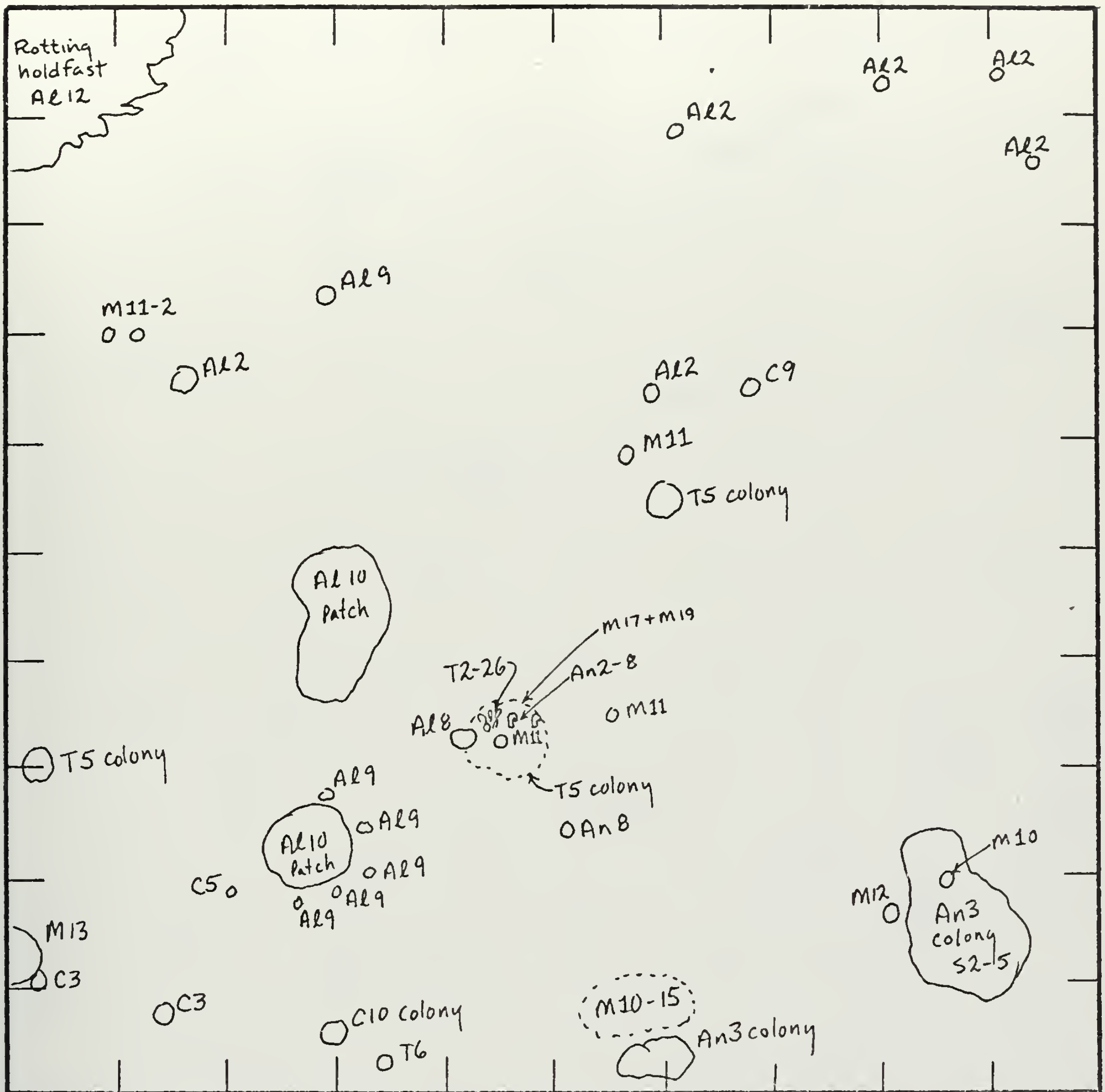


Figure 10. Subarea C2-A2

Remarks:

1. Moderately high surge and low (5-6 ft.) visibility experienced during mapping of this area may, in part, account for relatively low number of organisms observed.

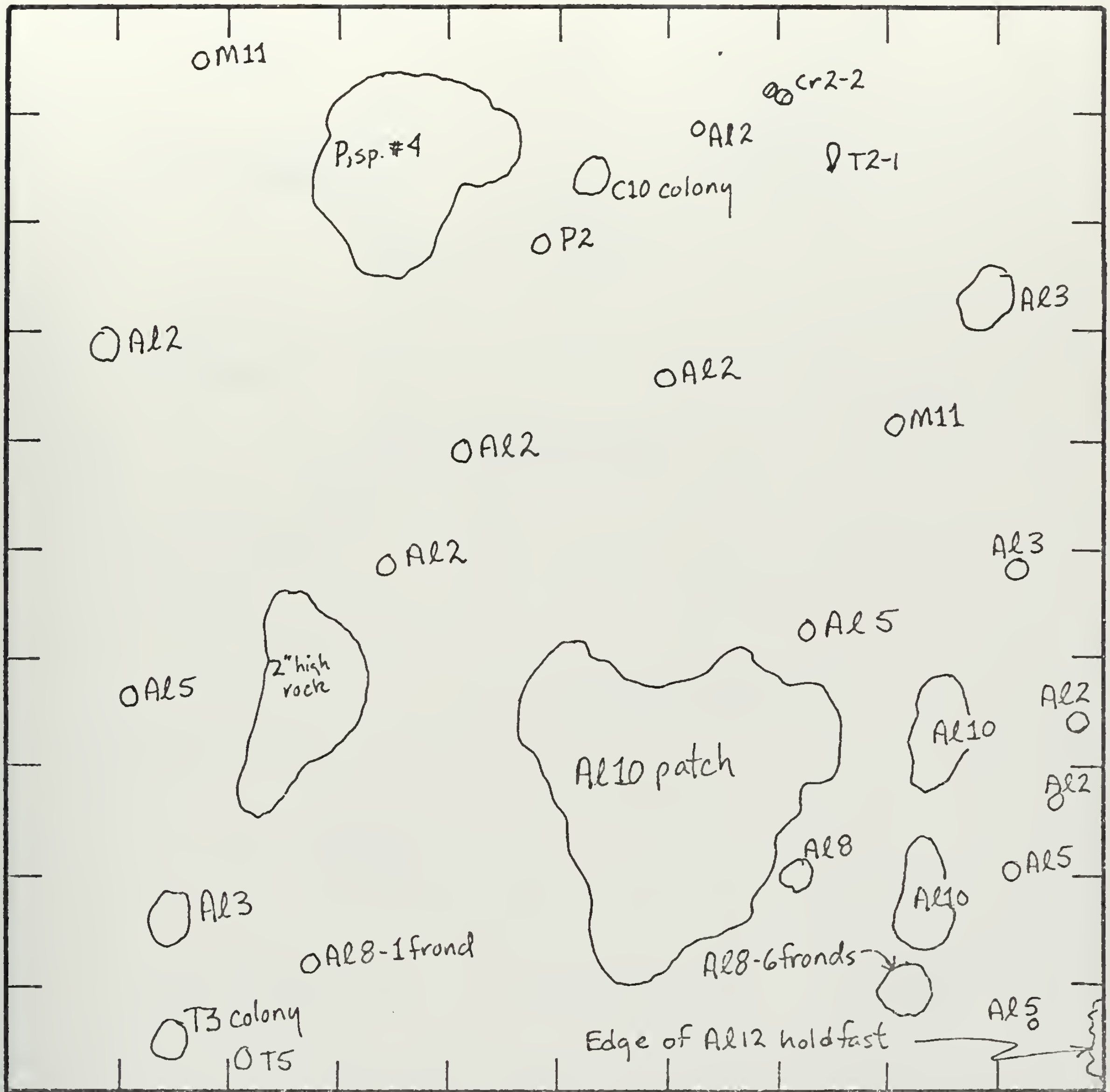


Figure 11. Subarea C2-A3

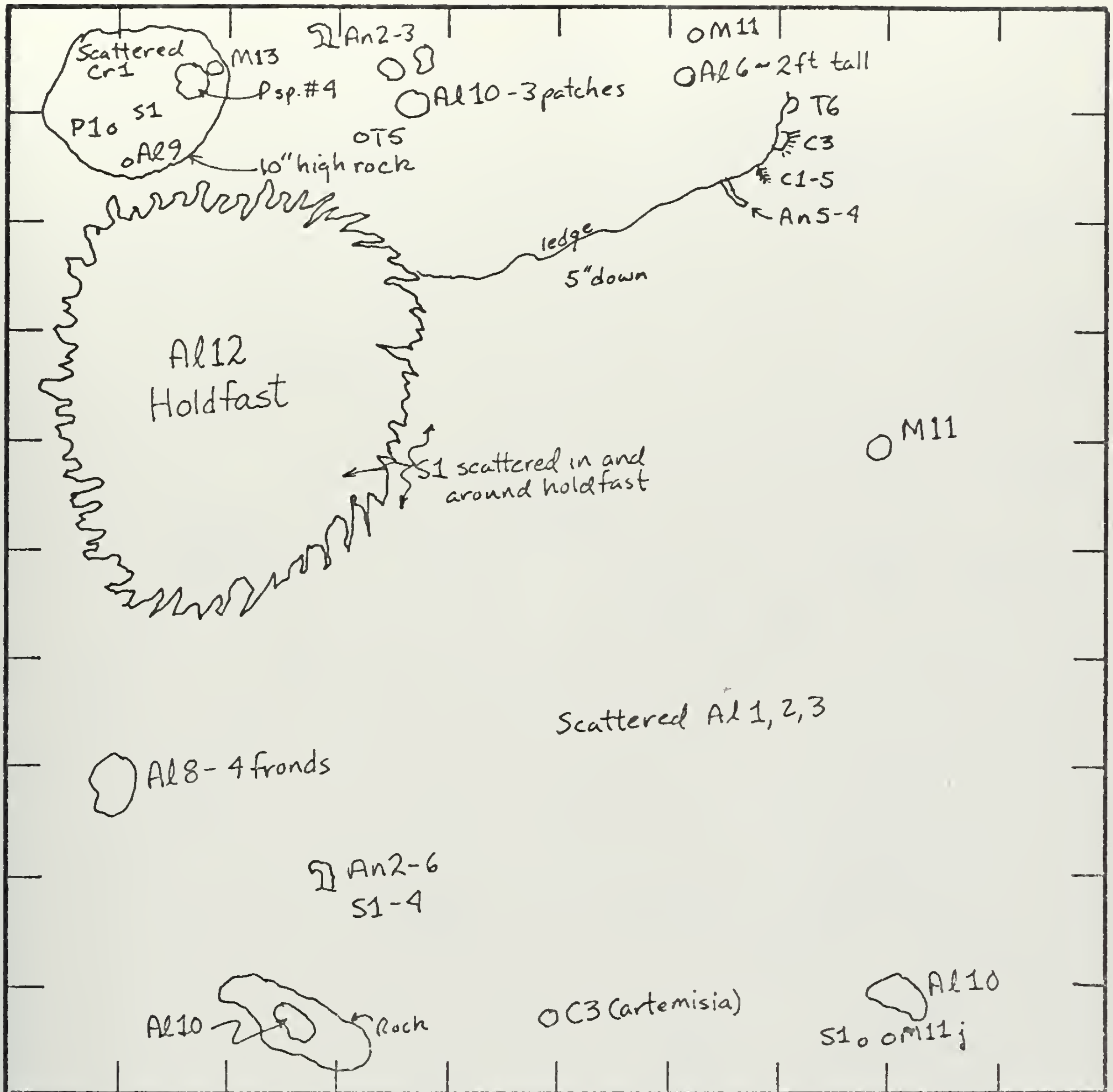


Figure 12. Subarea C2-B1

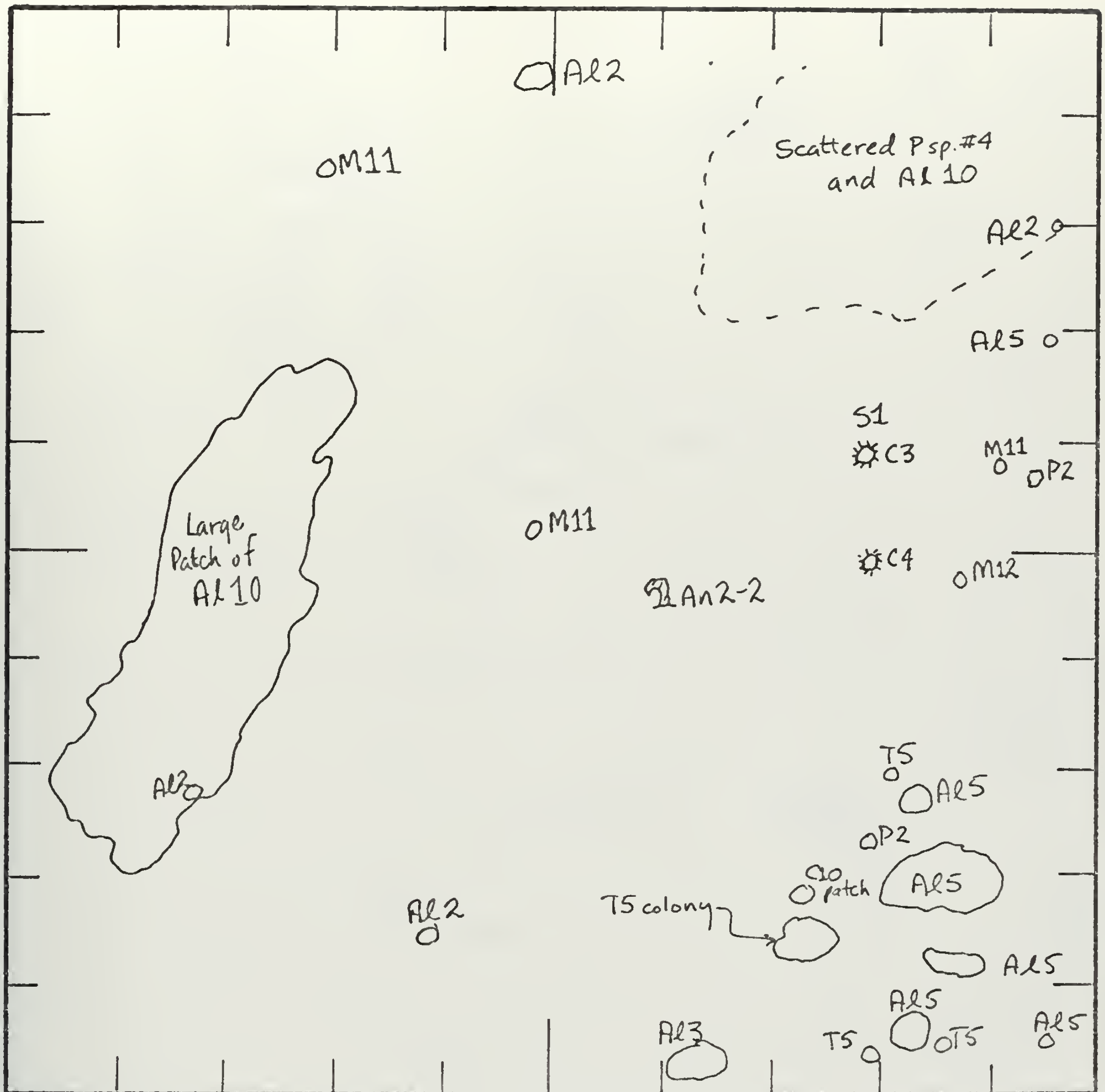


Figure 13. Subarea C2-B2

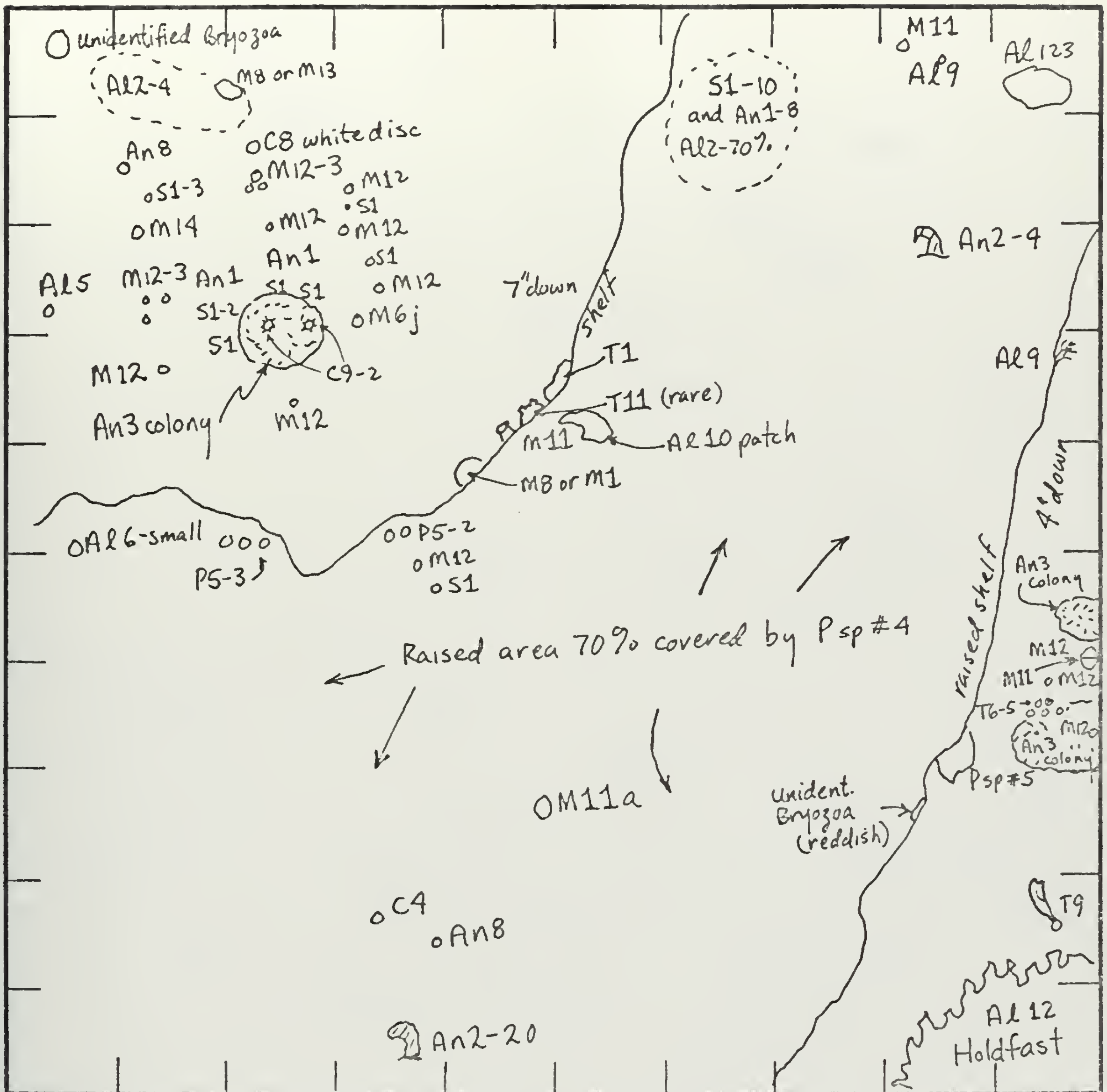


Figure 14. Subarea C2-B3

Remarks:

1. The unidentified bryozoa in upper left of figure was a thin, reddish, encrusting variety.
2. One squid egg case observed during mapping of this area on 19 July 1971.

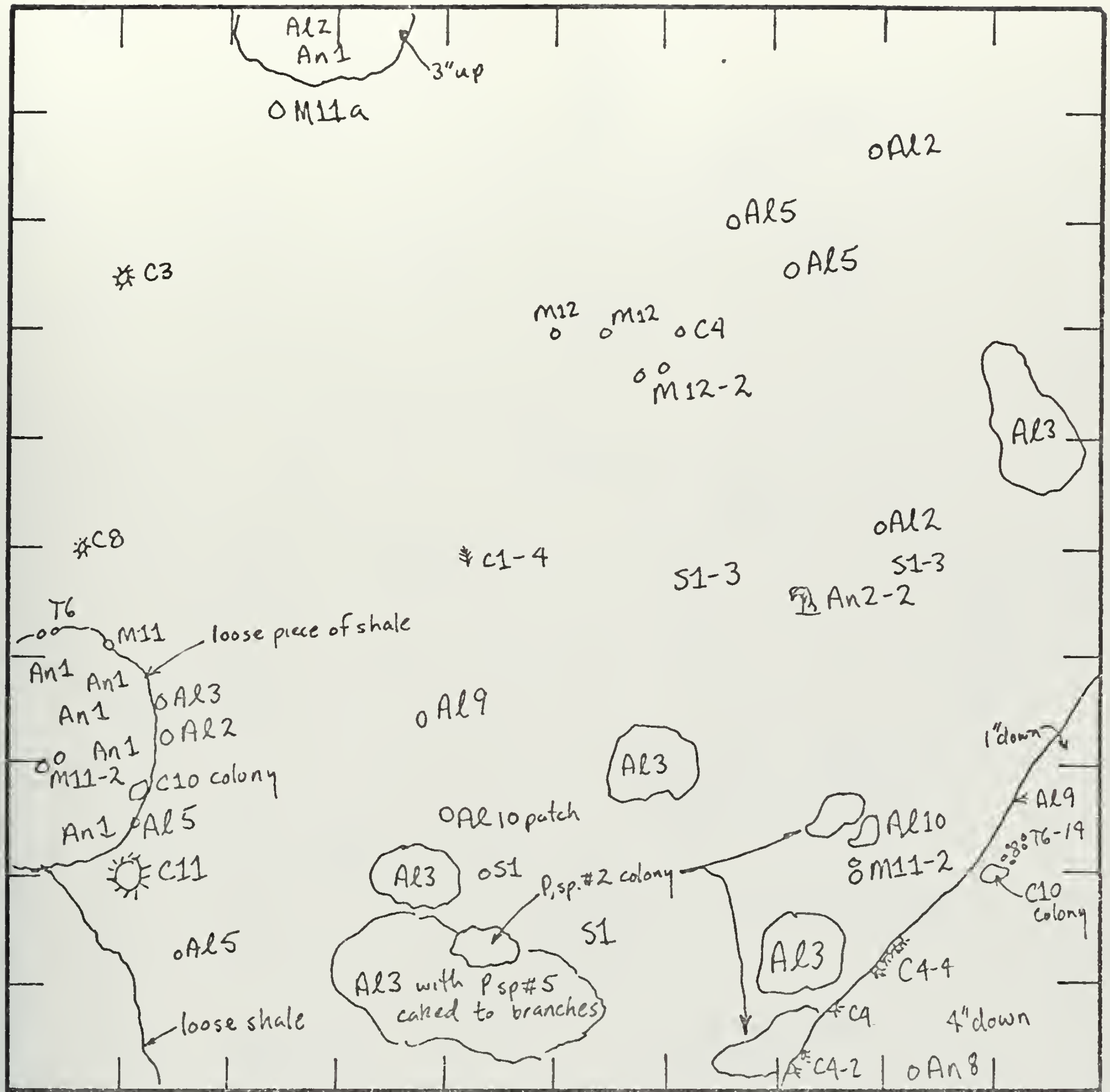


Figure 15. Subarea C2-C1

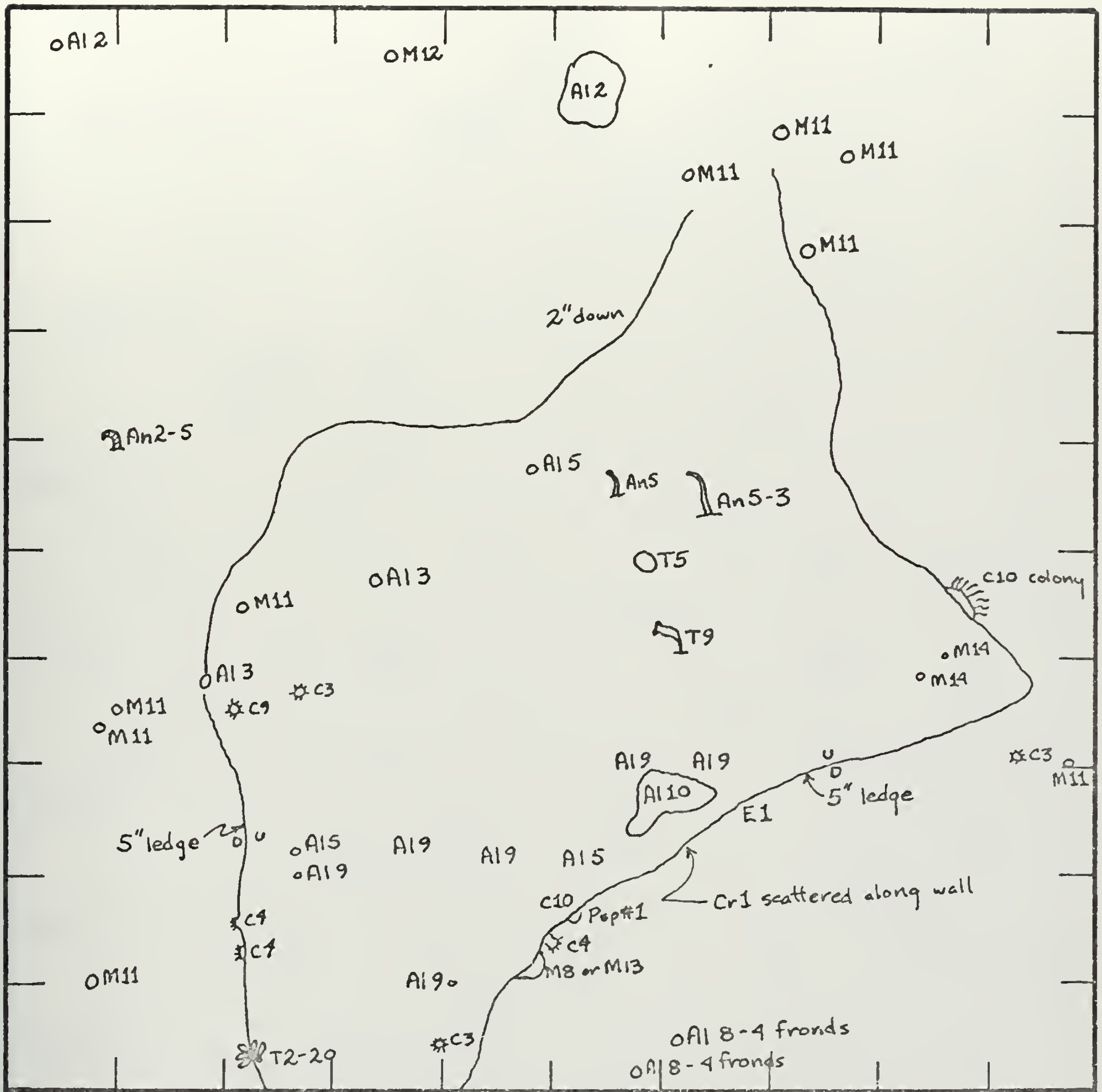


Figure 17. Subarea C2-C2

Remarks:

1. One unidentified hermit crab using what appeared to be a small piece of twig for a shell was observed in this area.

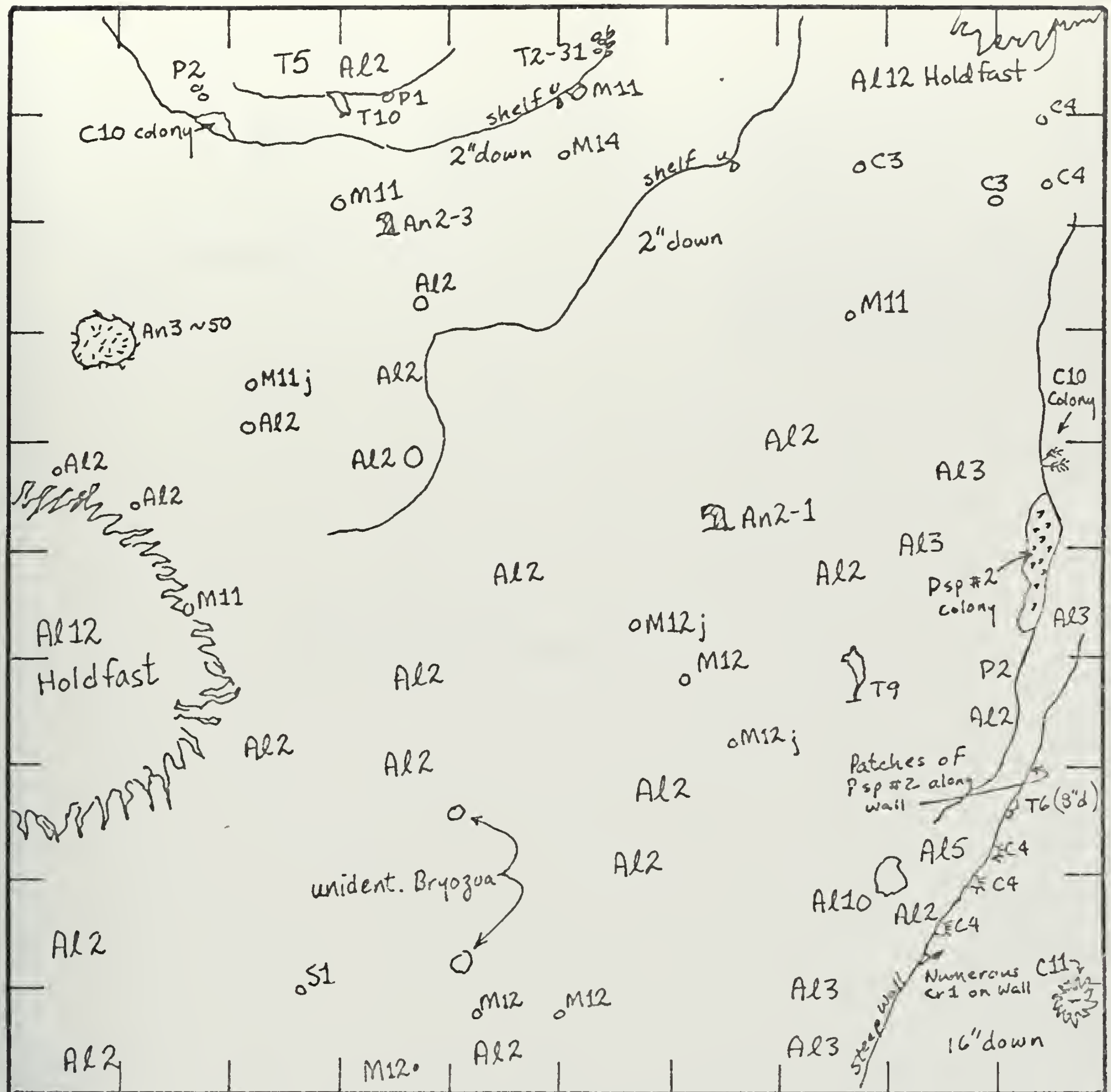


Figure 18. Subarea C2-C3

Remarks:

1. Not illustrated are the small Balanus crenatus observed in large numbers on the vertical face of the ledge plotted in the lower right hand corner of the figure.

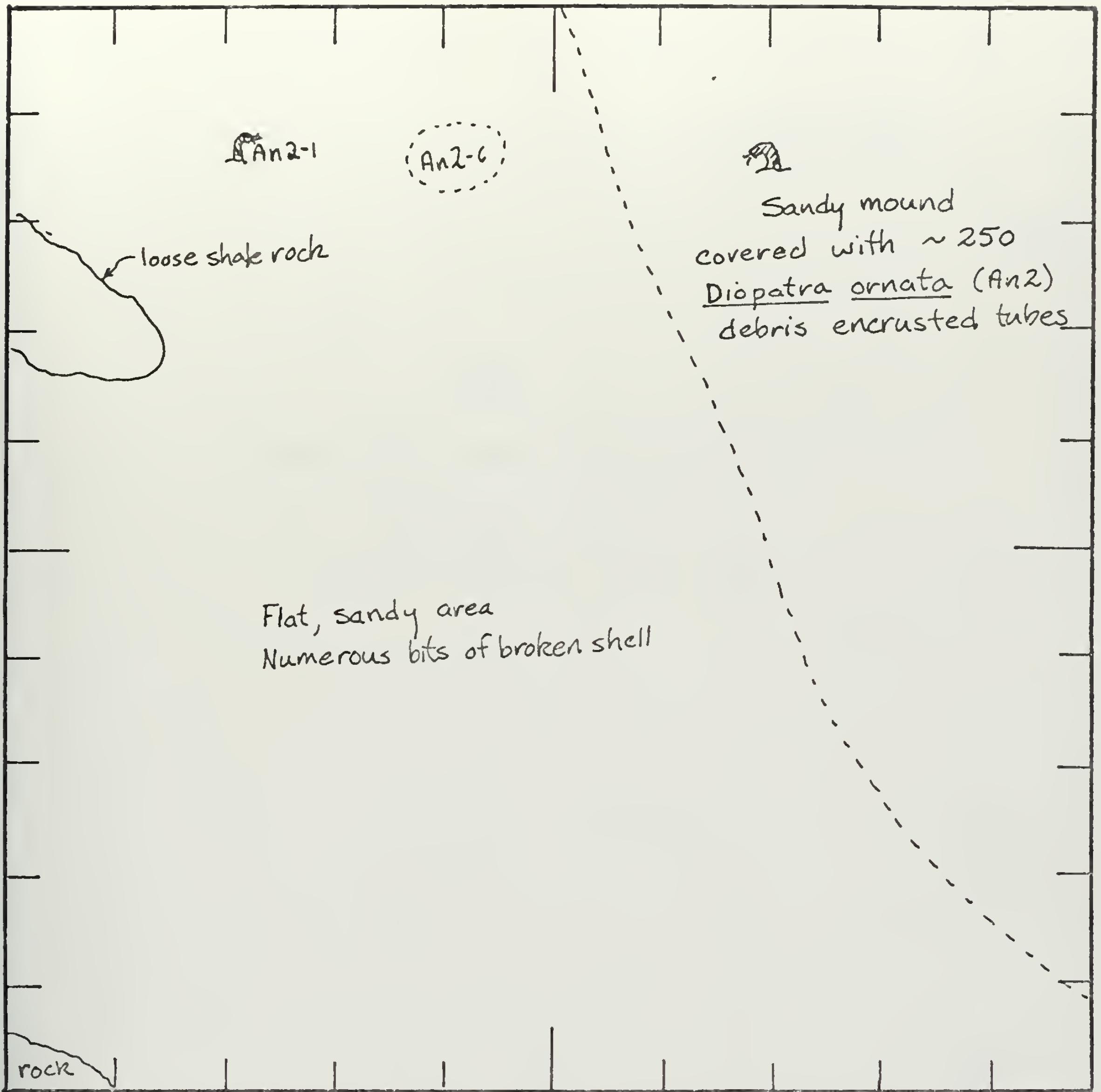


Figure 19. Subarea D2-A1

Remarks:

1. Small colonies of Plumularia spp. (C10) were observed on approximately 5% of the worm tubes.
2. The hook-shaped Diopatra ornata (An 2) tubes appeared to be more than 90% occupied by living animals.

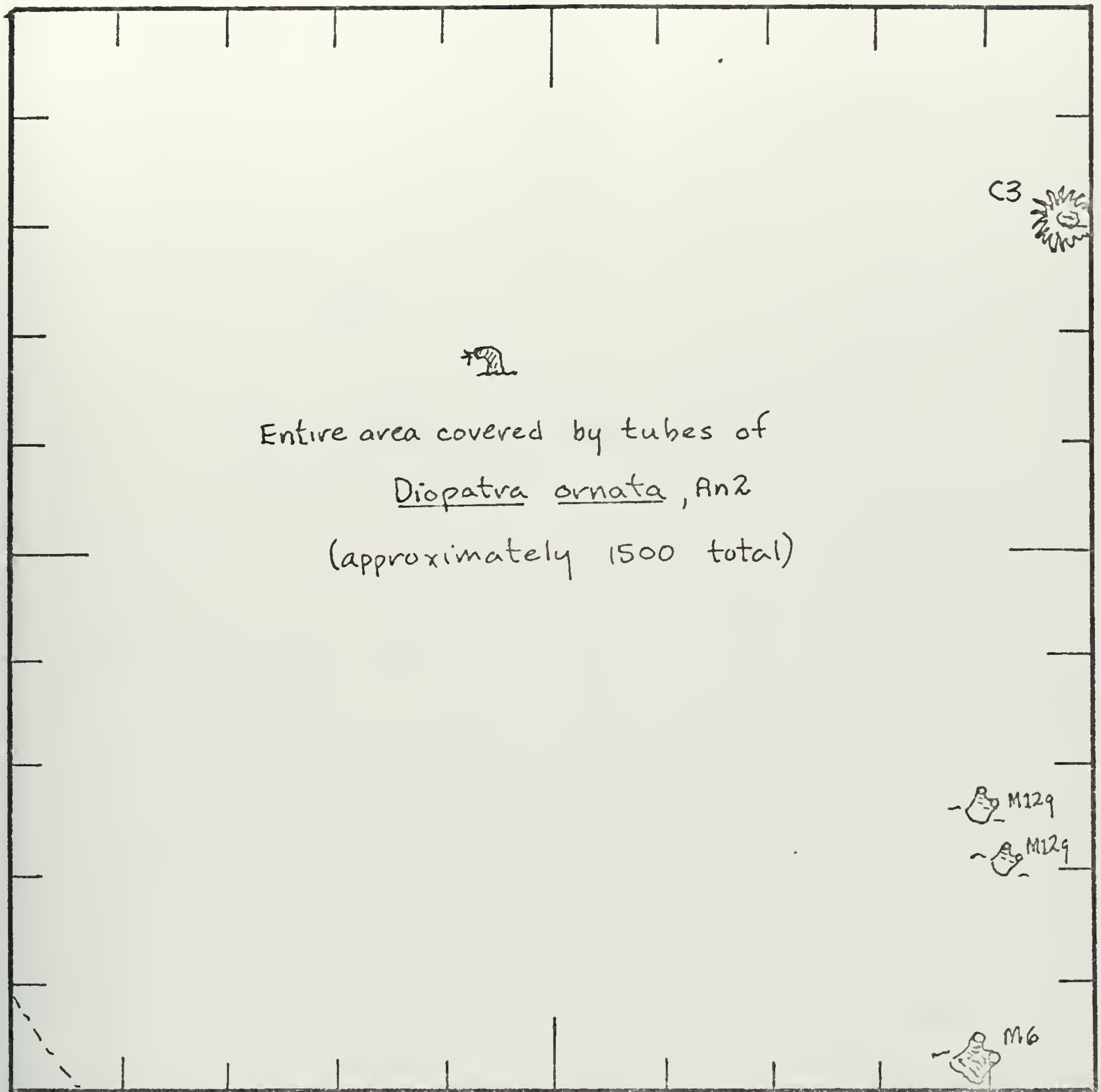


Figure 20. Subarea D2-A2

Remarks:

1. The worm tubes were embedded in a large sandy mound.

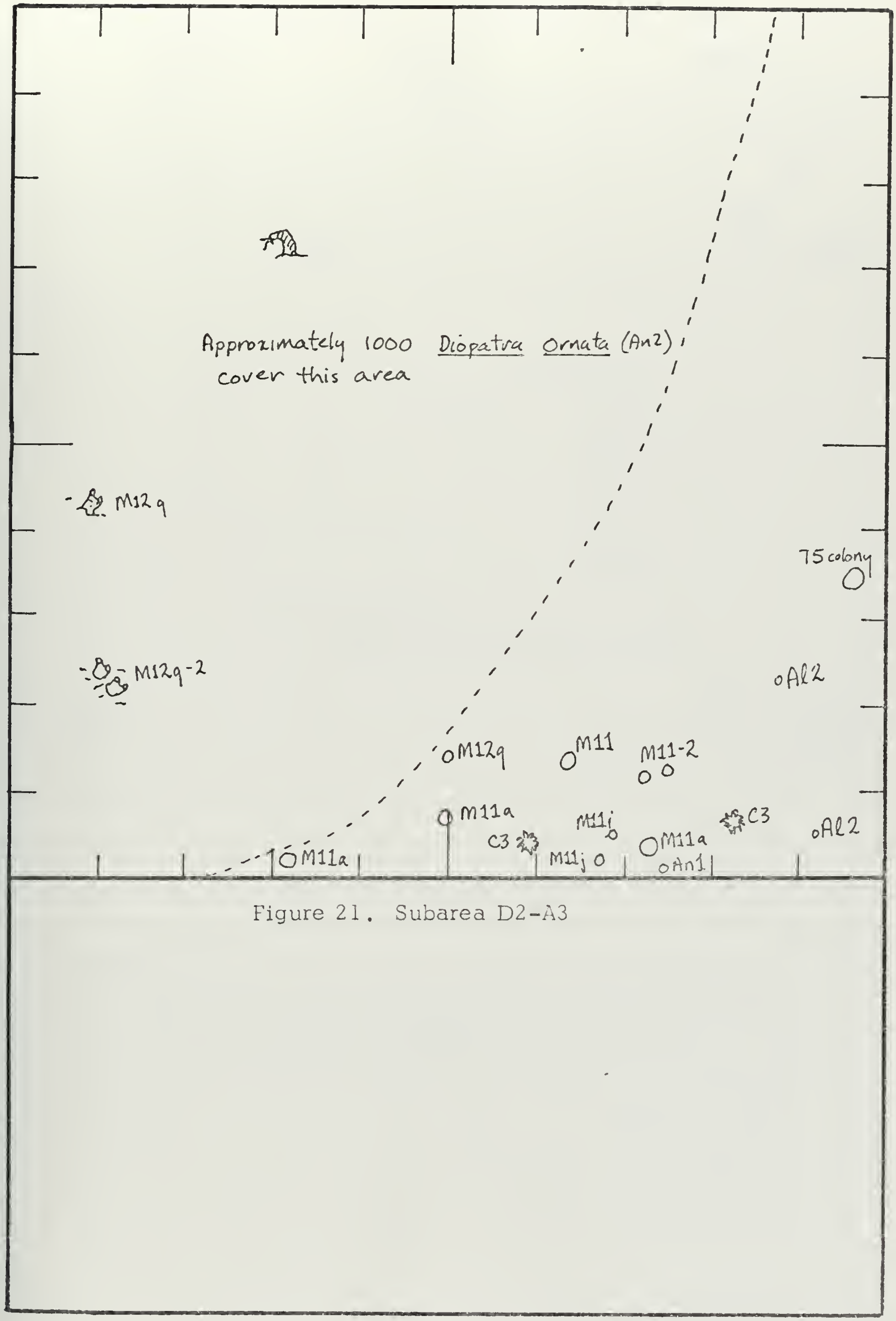


Figure 21. Subarea D2-A3

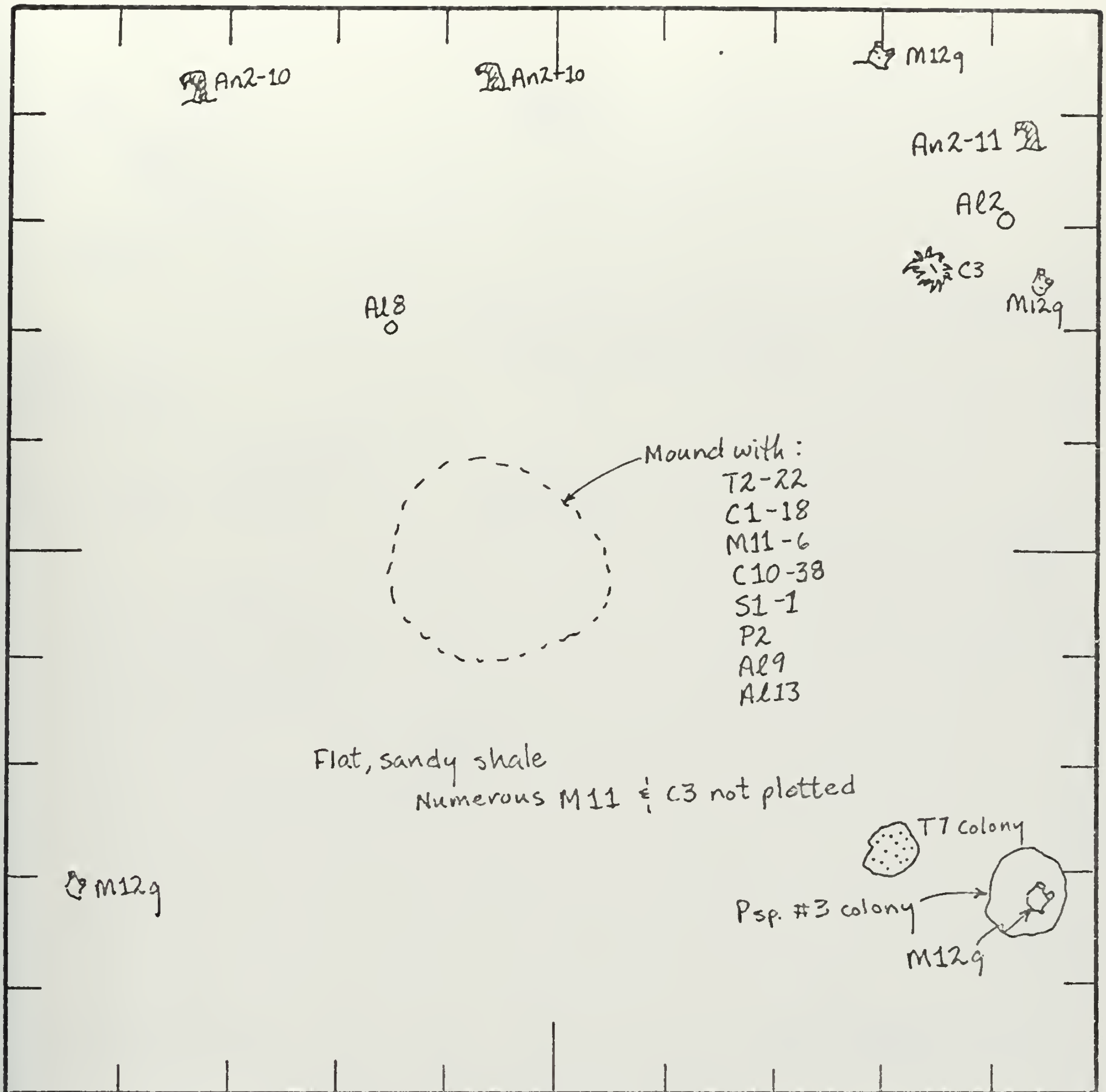


Figure 22. Subarea D2-A4

Remarks:

1. Heavy surge was experienced during the mapping of this area and it is likely that a number of organisms present were not observed.

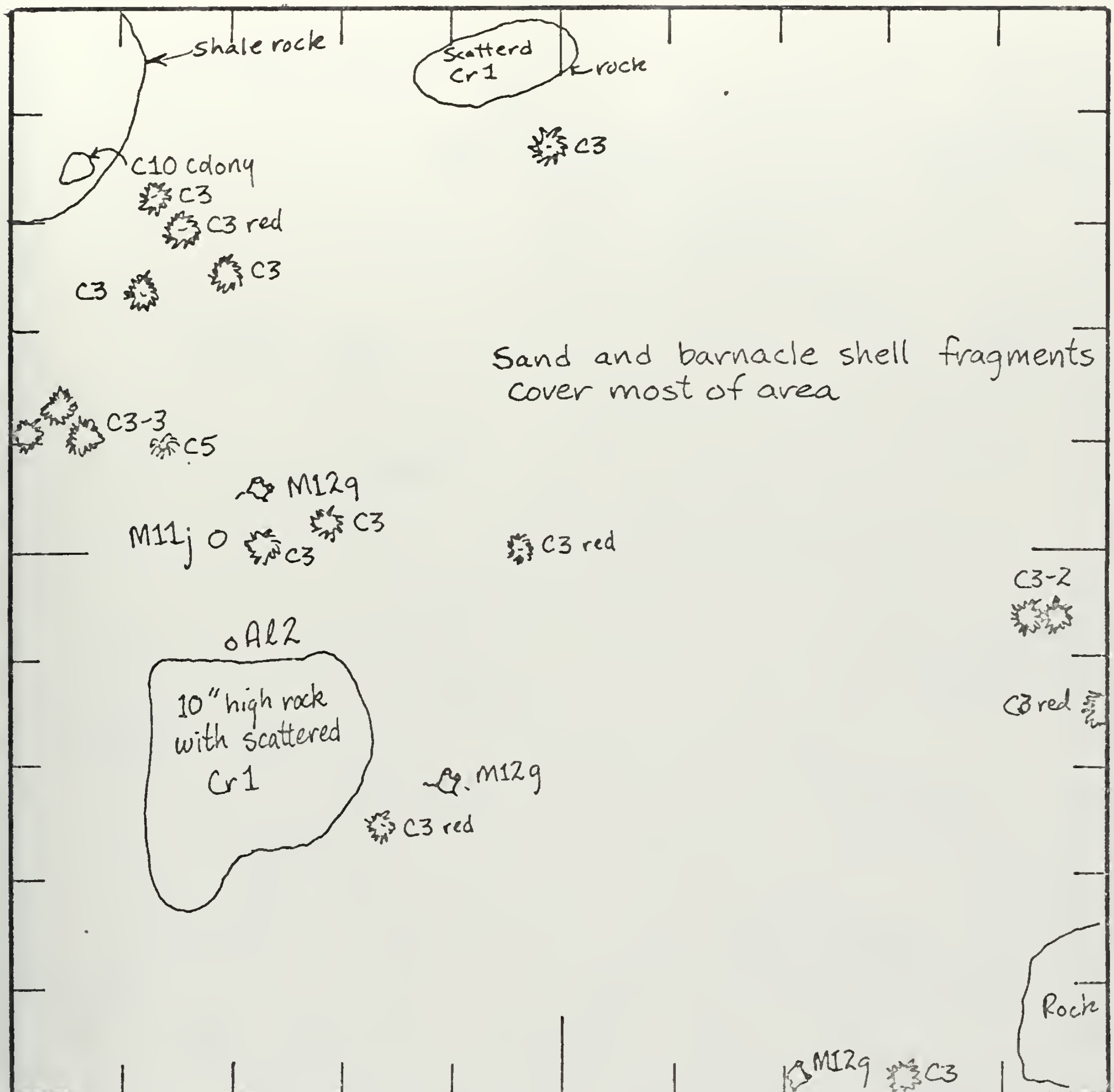


Figure 23. Subarea D2-B1

Remarks:

1. Most of the anemonies plotted as C3 were Anthopleura artimissia rather than A. Elegantissima.
2. A Neoclinus uninotatus was observed eating Balanus crenatus.

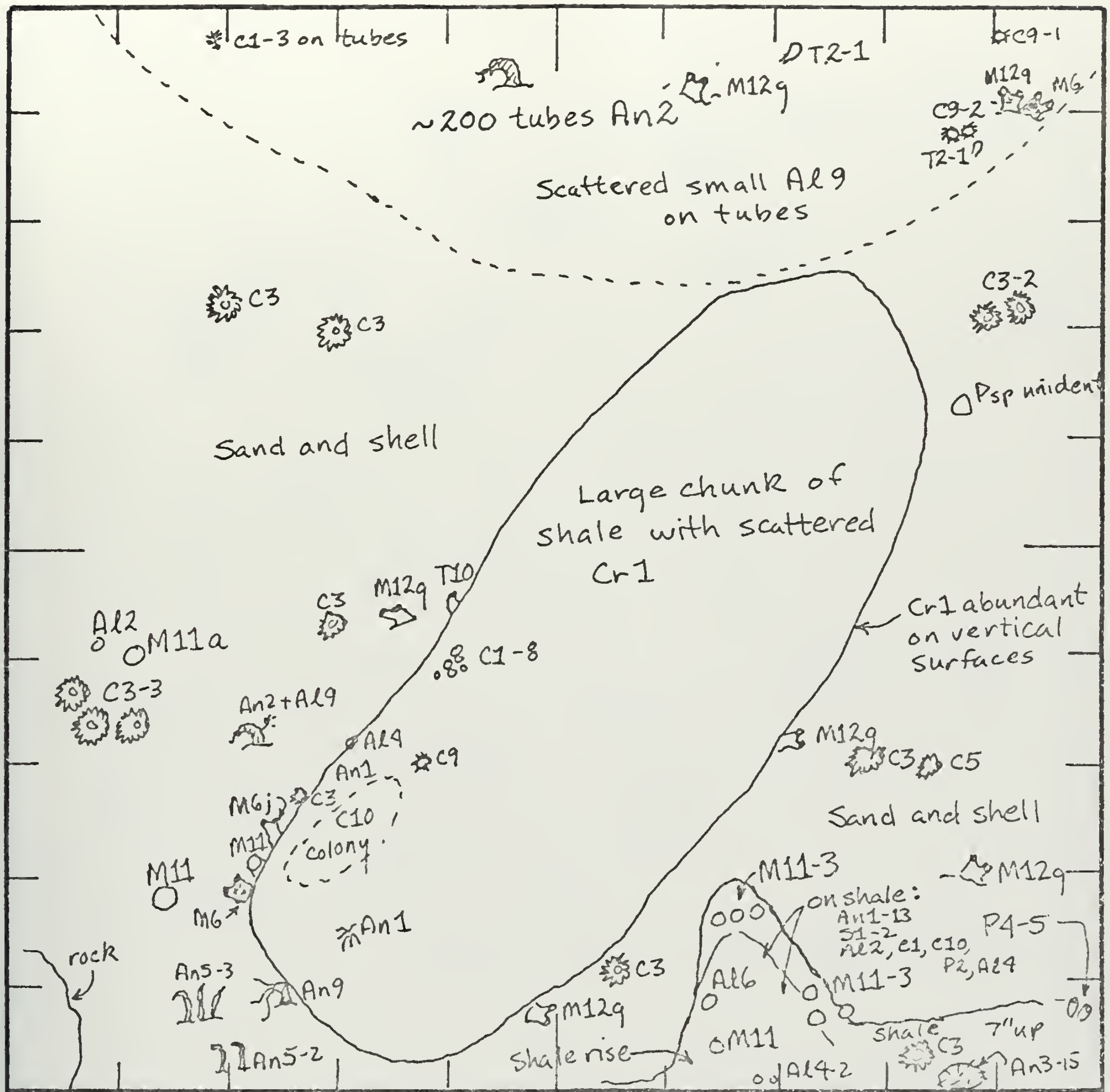


Figure 24. Subarea D2-B2

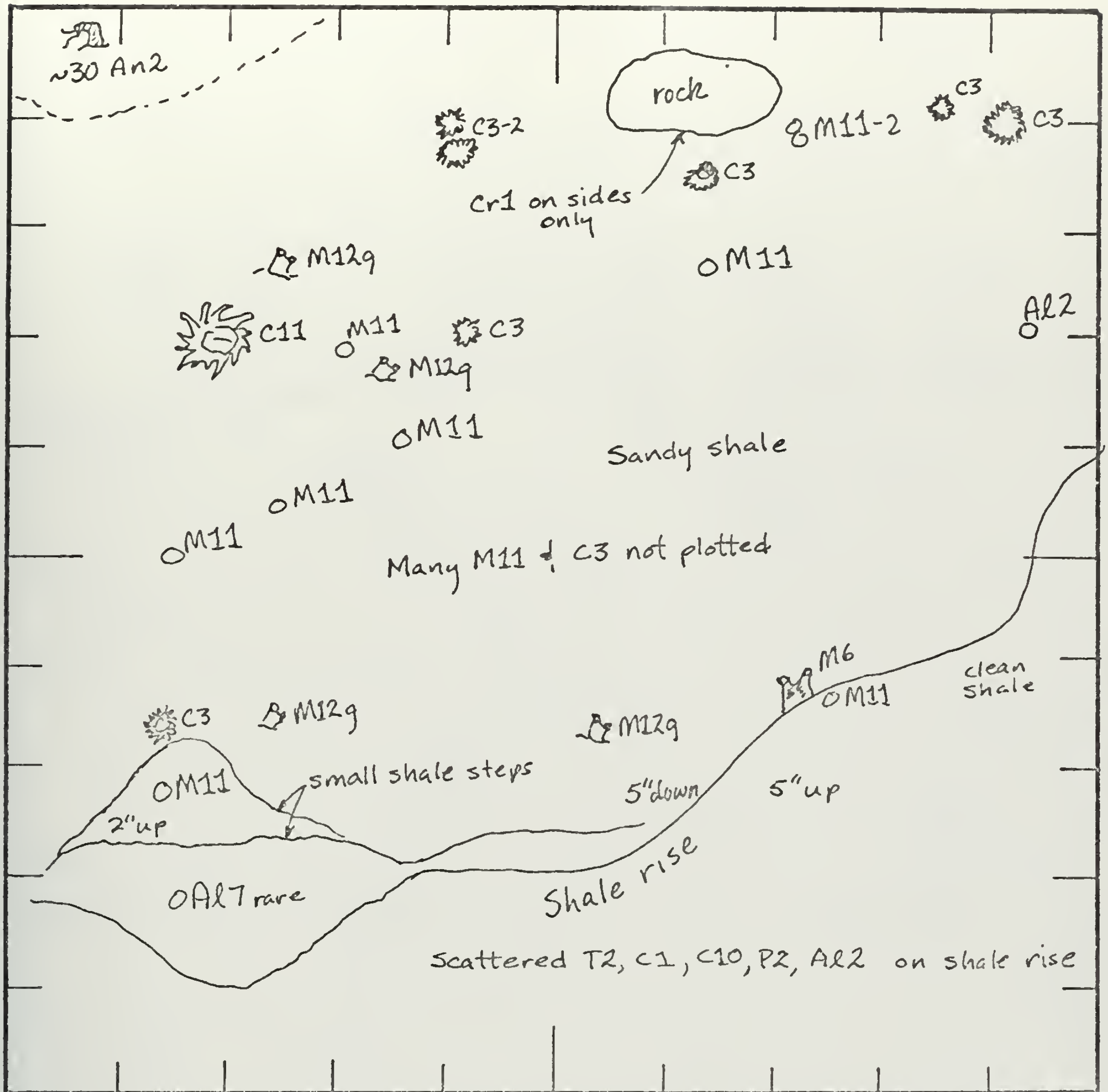


Figure 25. Subarea D2-B3

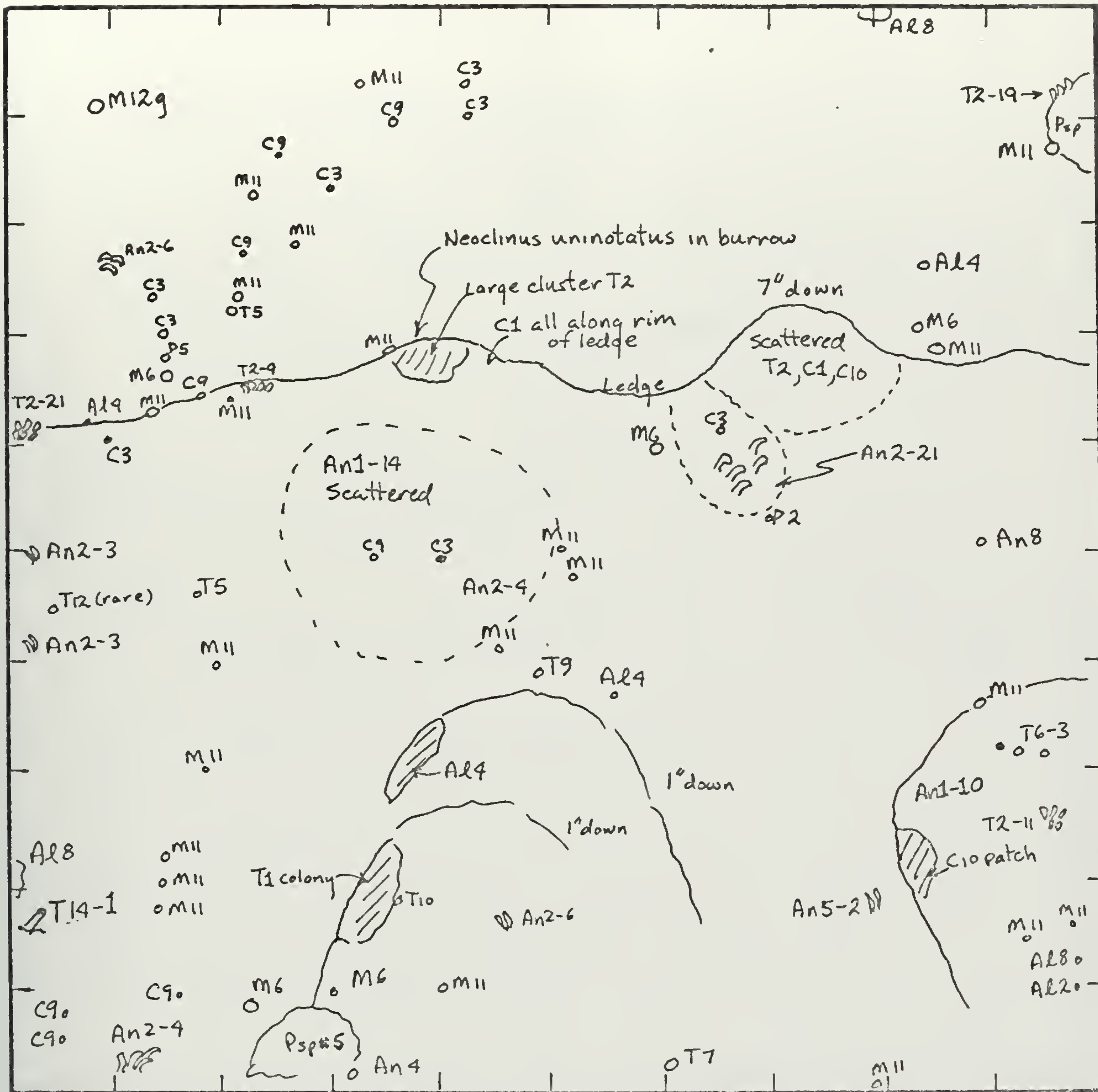


Figure 26. Subarea D2-B4

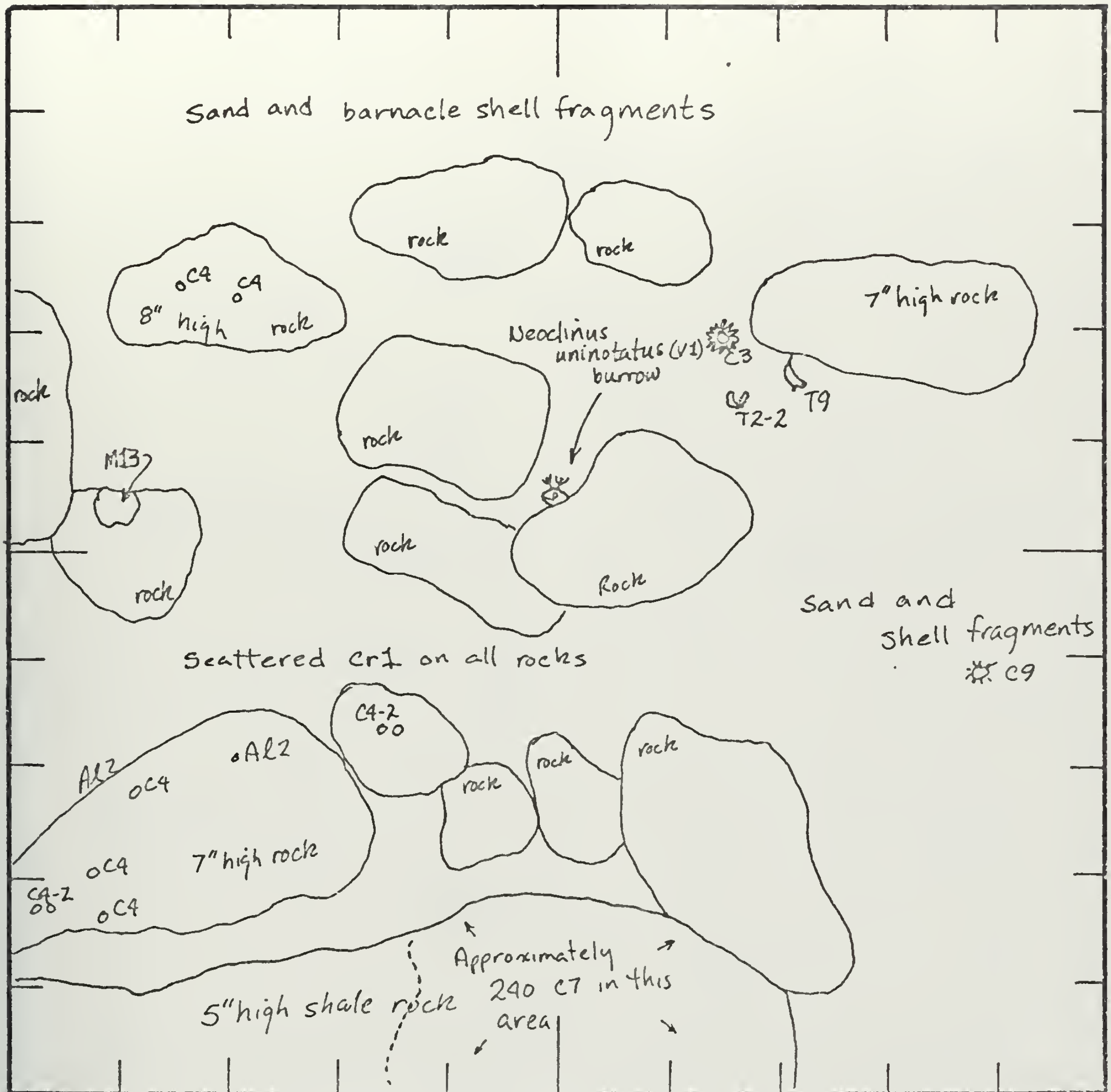


Figure 27. Subarea D2-C1

Remarks:

1. The rocks plotted were chunks of loose shale probably broken off of the large ledge in row D.

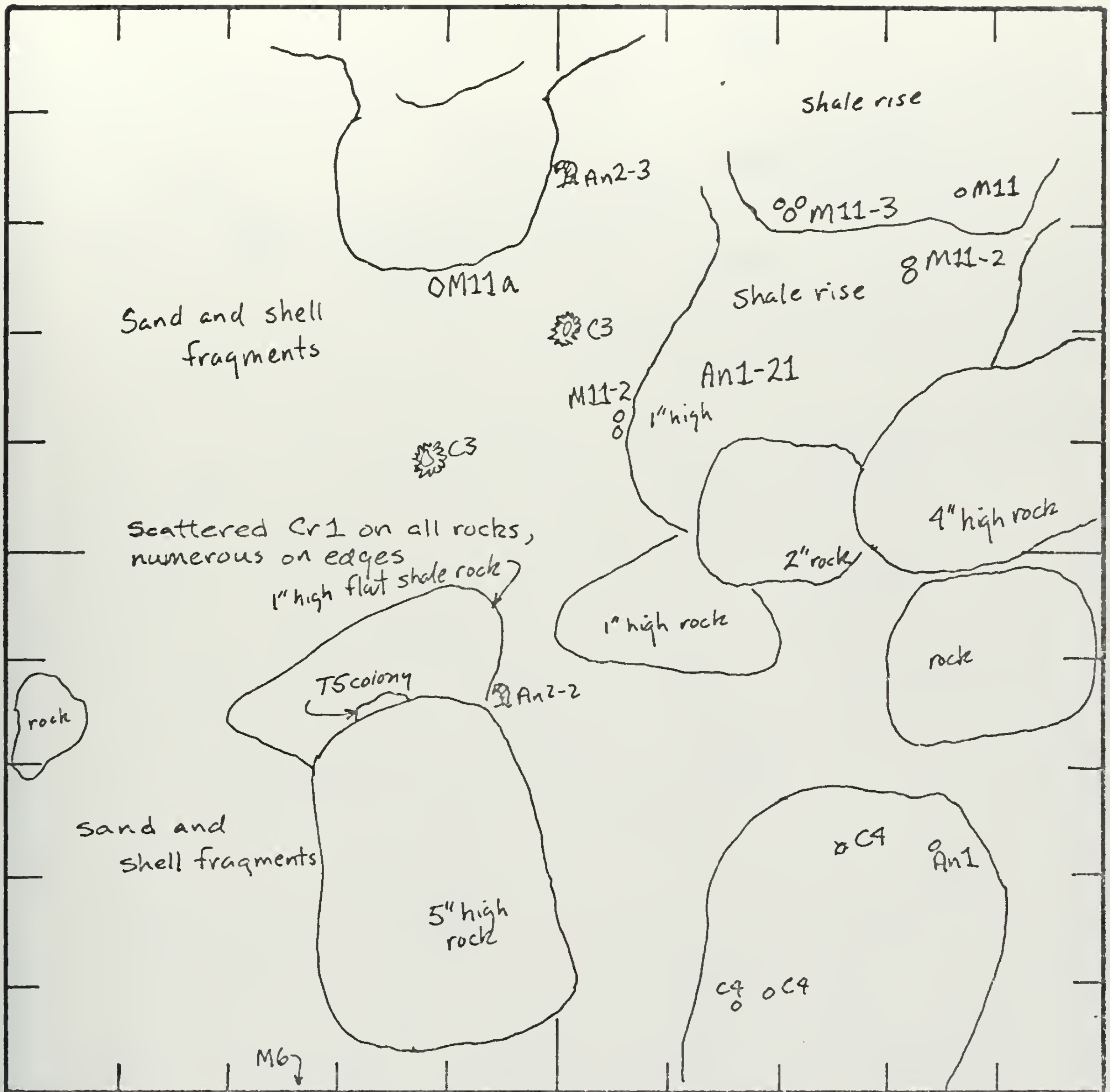


Figure 28. Subarea D2-C2

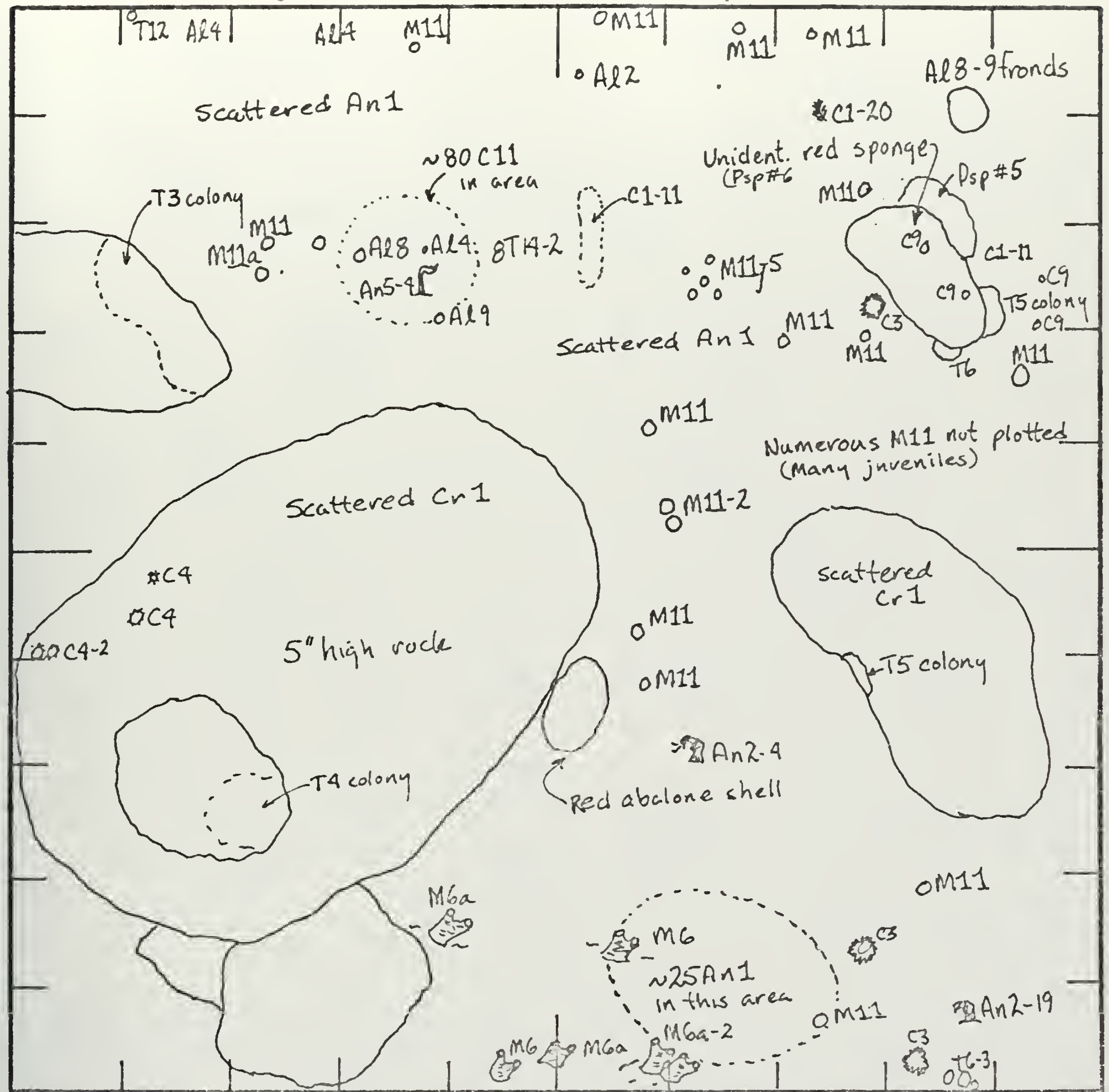


Figure 29. Subarea D2-C3

Remarks:

1. This was a heavily populated area and probably a number of organisms were missed in mapping and counting.

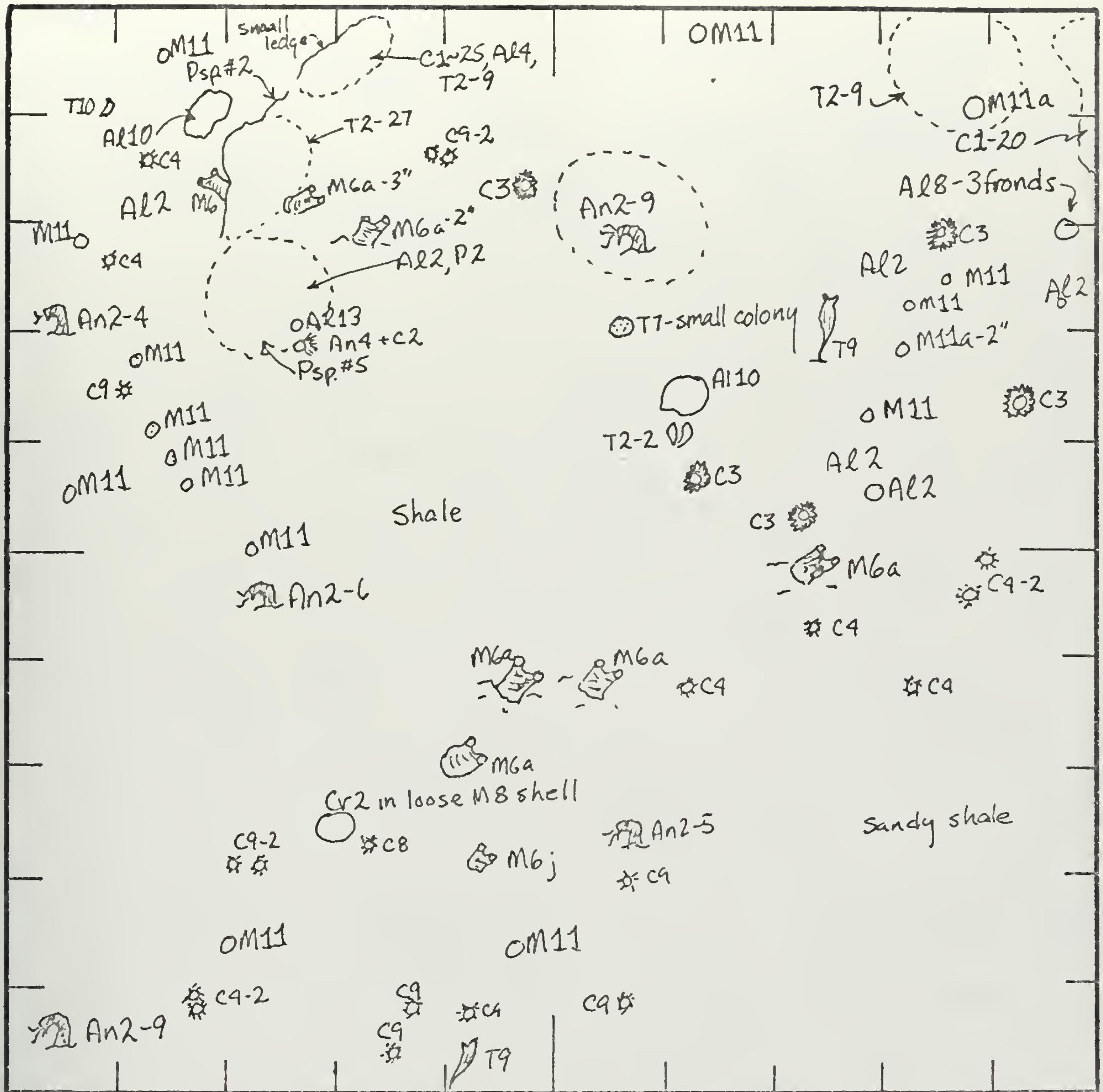


Figure 30. Subarea D2-C4

Remarks:

1. Same as for area D2-C3.

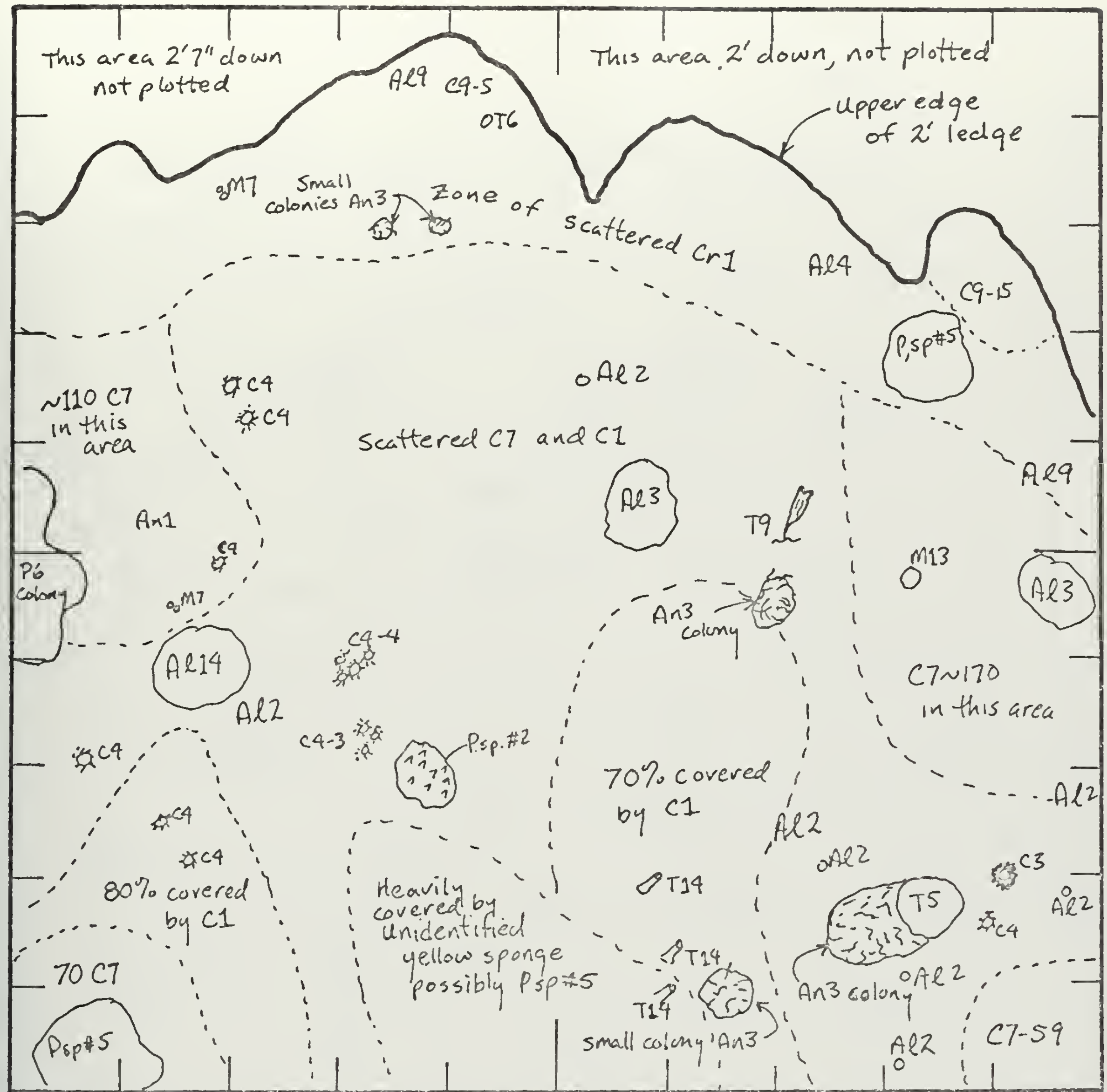


Figure 31. Subarea D2--D1

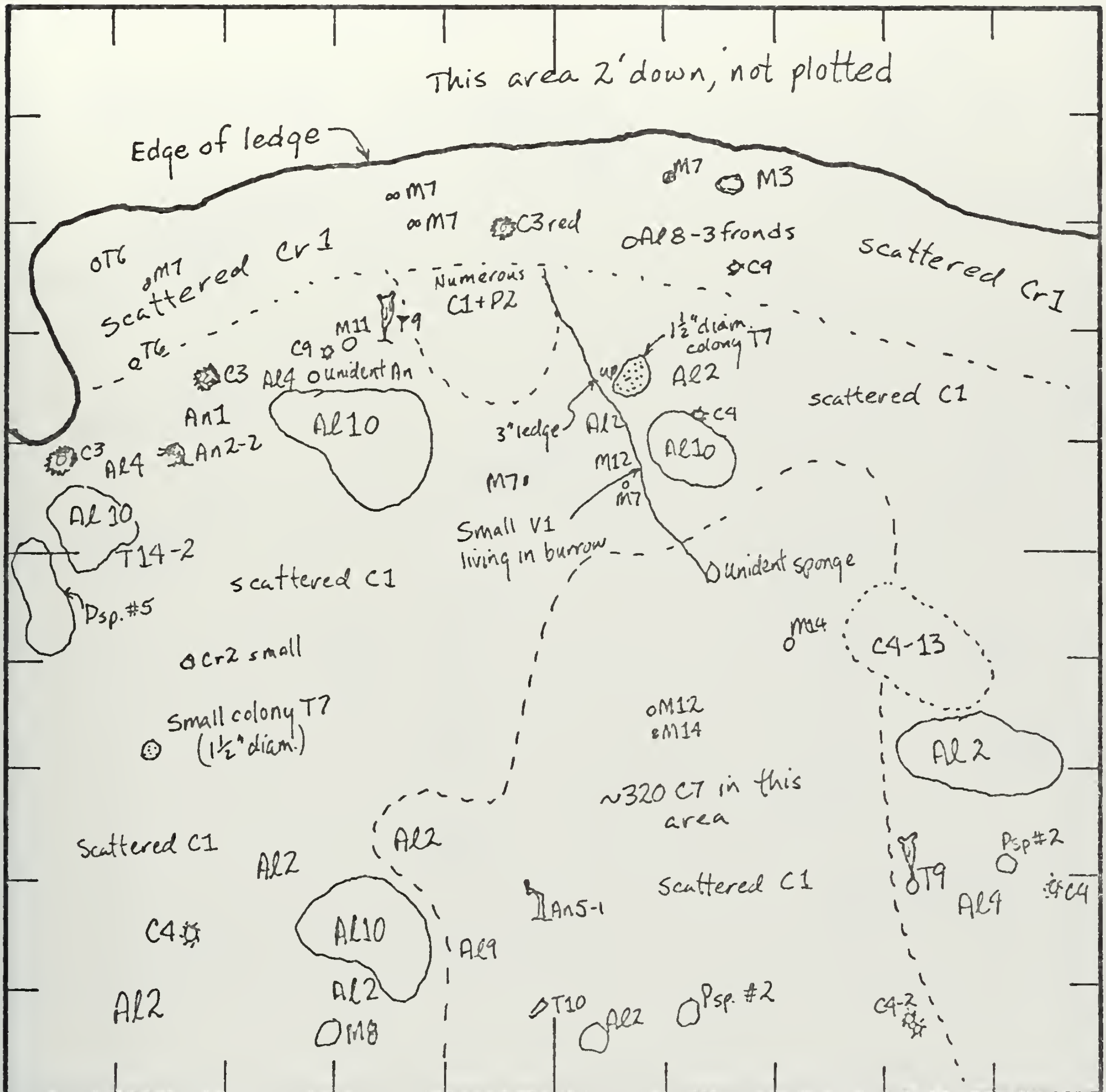


Figure 32. Subarea D2-D2

Remarks:

1. One unidentified nudibranch believed to be *Rostanga pulchra* observed.

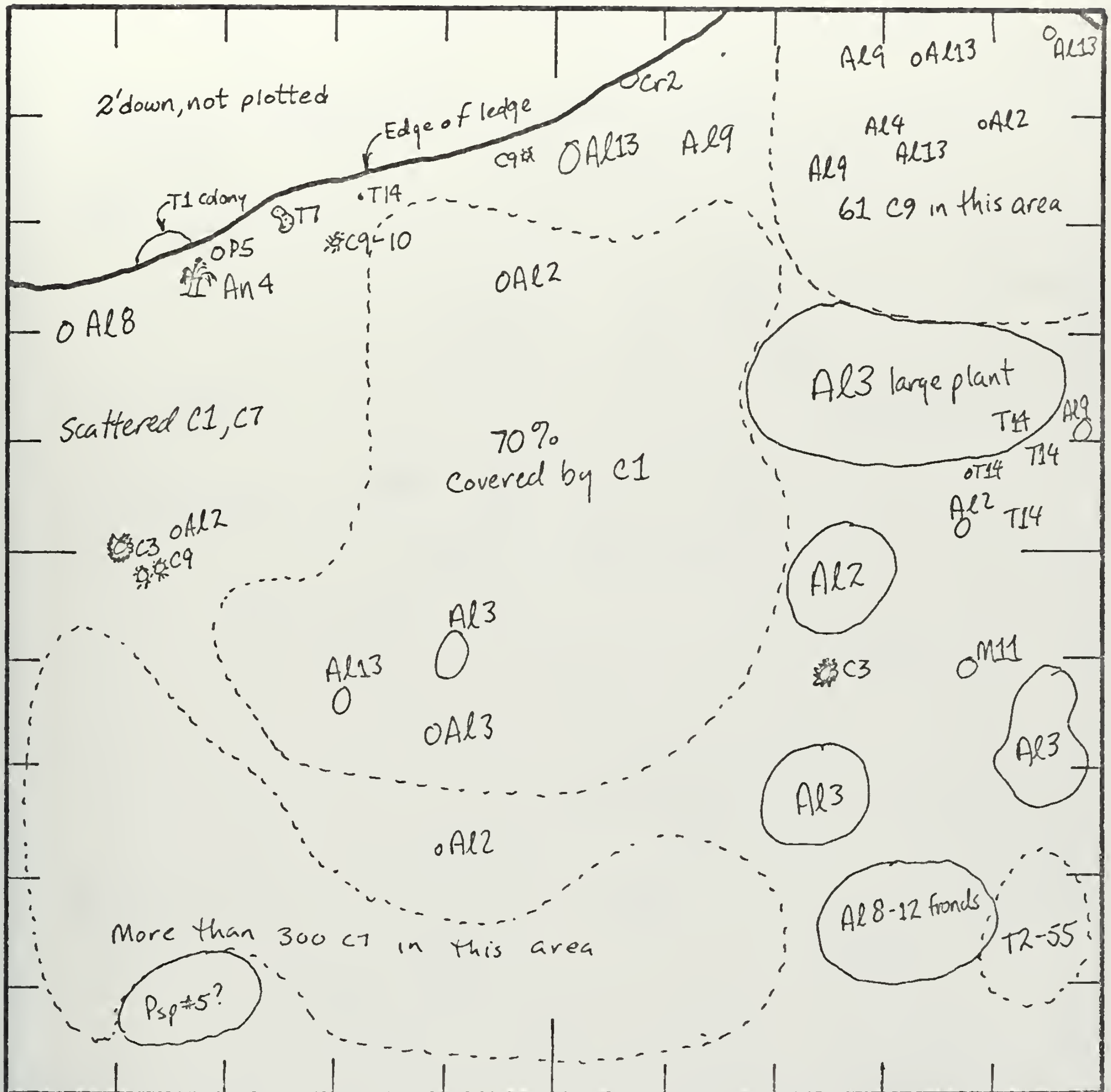


Figure 33. Subarea D2-D3

Remarks:

1. The Henricia leviuscula observed (but not plotted) in this area had six rays.

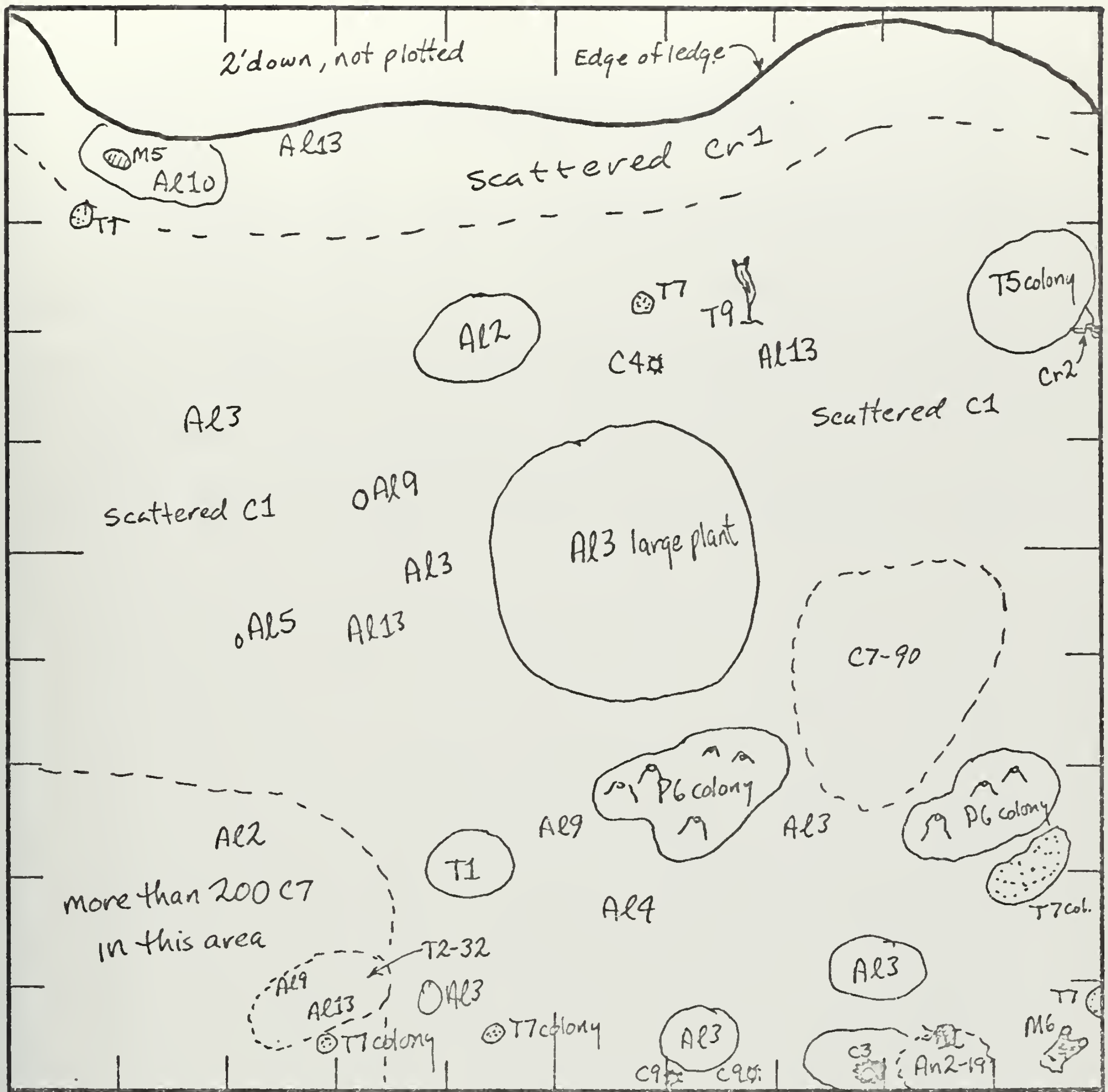


Figure 34. Subarea D2-D4

APPENDIX B: SUBAREA PHOTOGRAPHS

In this Appendix photographs of C2 and D2 by one-meter-square subareas are presented. The bottom water at C2 is nearly always a bit murky and thus the quality of these photographs is not quite as good as that of the D2 pictures. With the exception of the ledge photographs in D2 all shots were taken in the same orientation as the subarea maps (Appendix A).

Figure 35. Subarea C2-A1

Figure 36. Subarea C2-A2

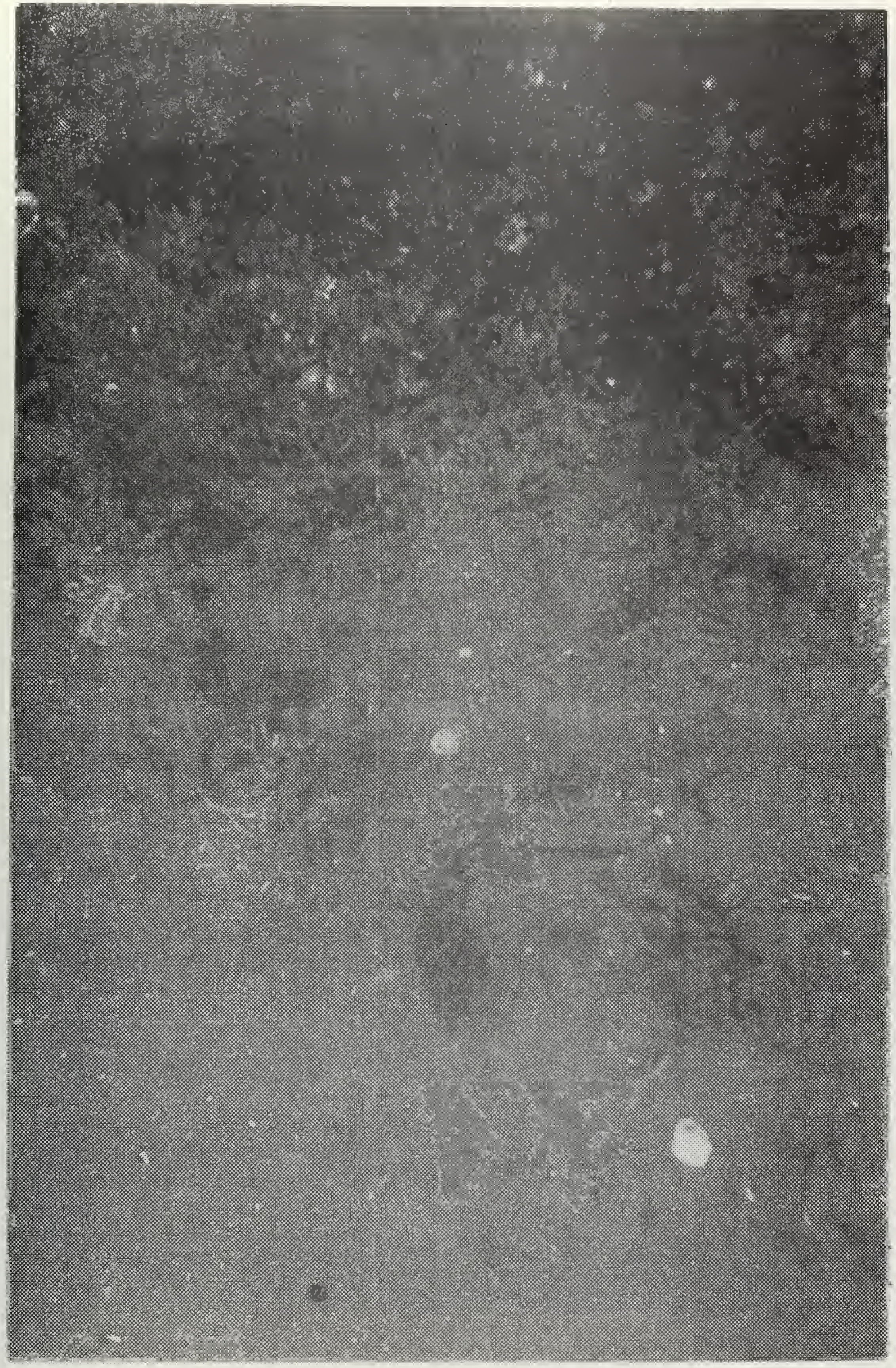


Figure 37. Subarea C2-A3

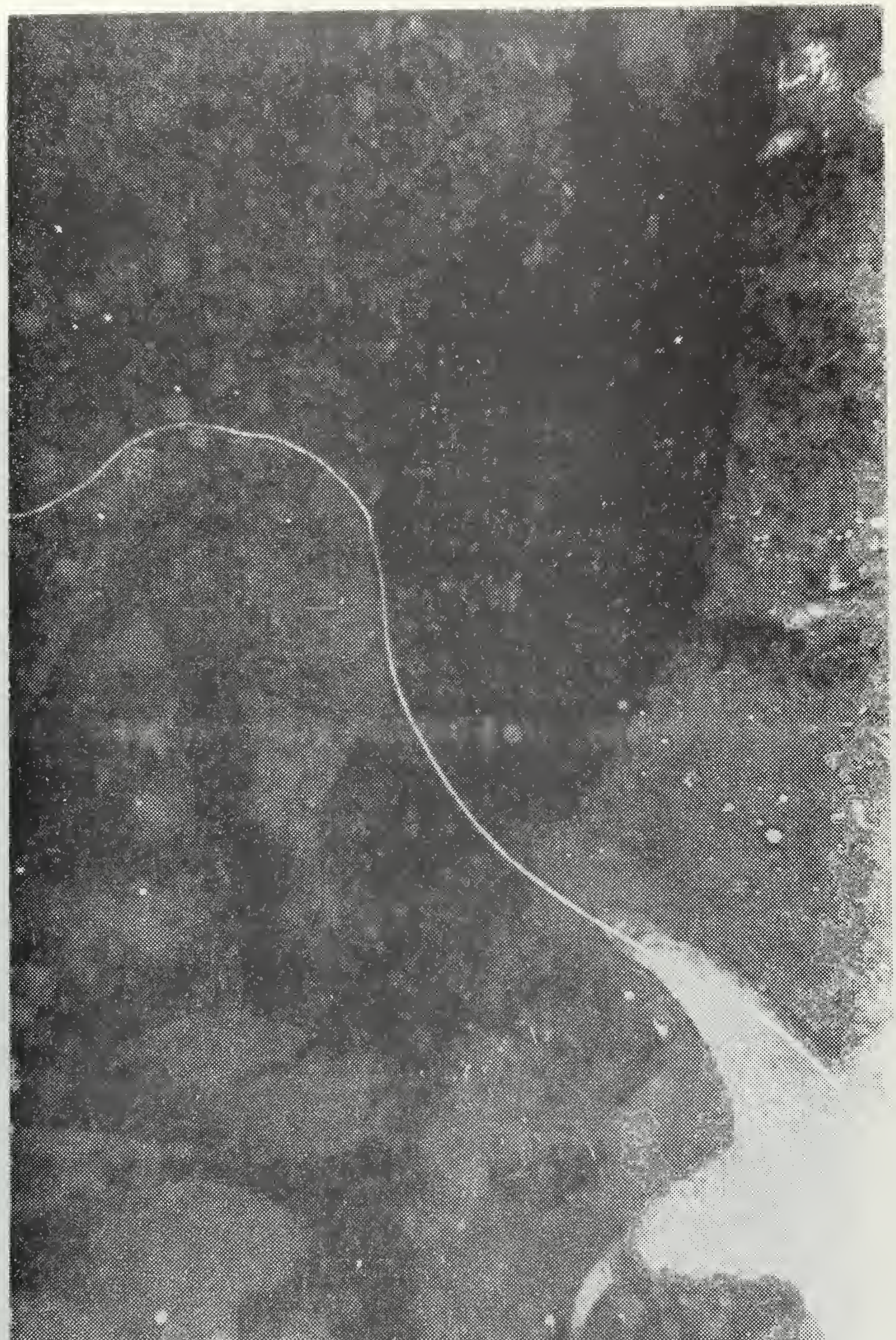


Figure 38. Subarea C2-B1

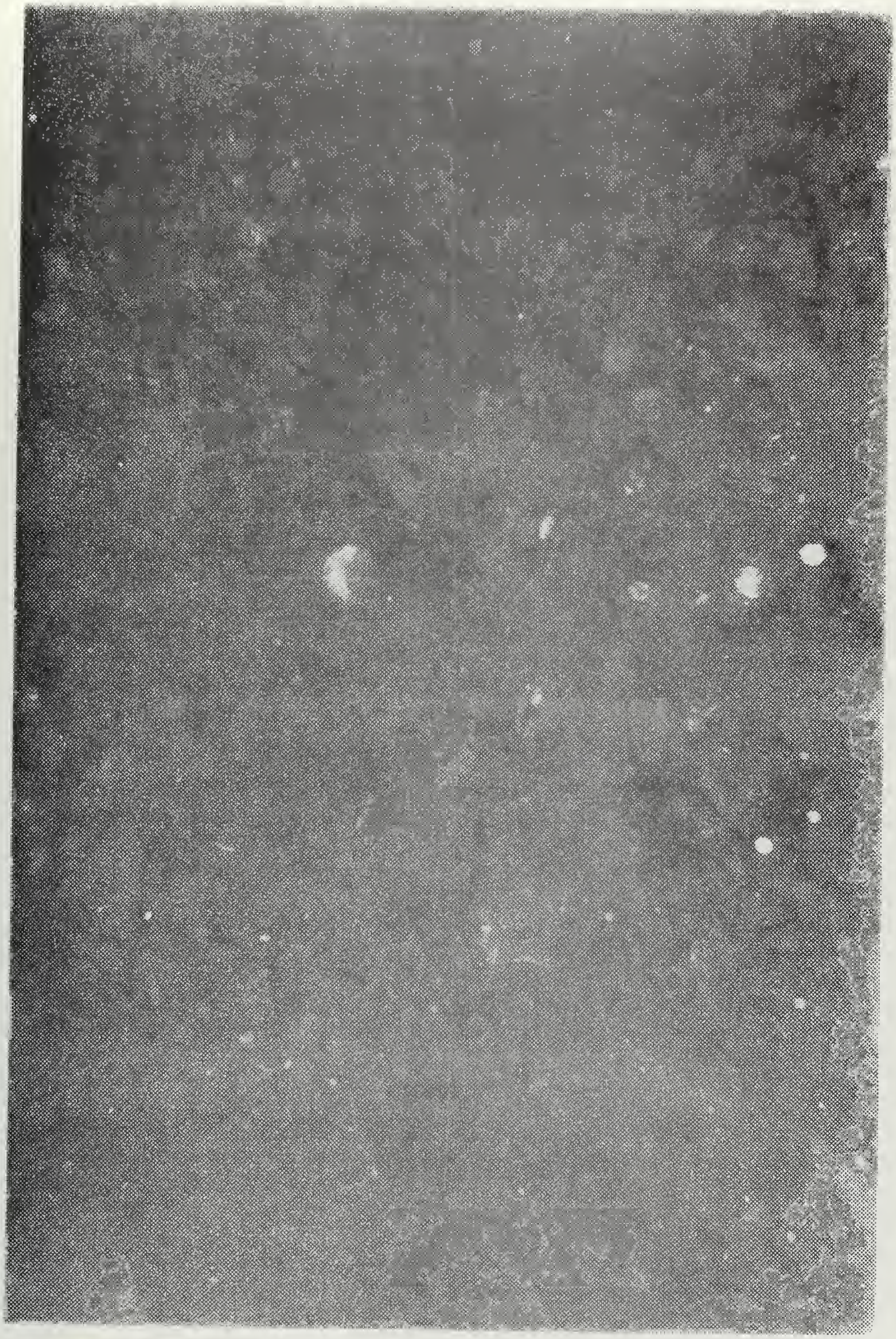


Figure 39. Subarea C2-B2

Figure 40. Subarea C2-B3

Figure 41. Subarea C2-C1

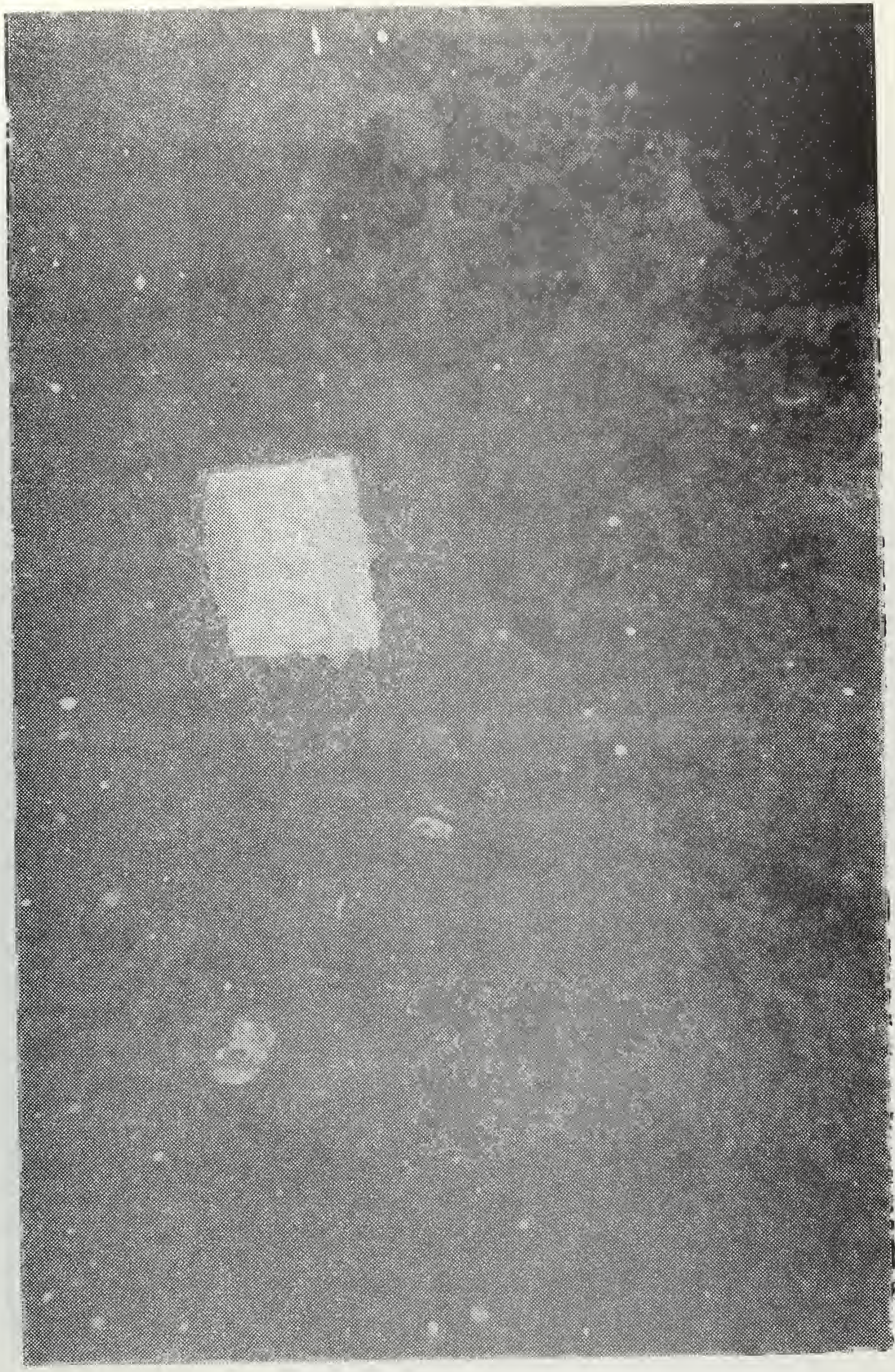


Figure 42. Subarea C2-C2

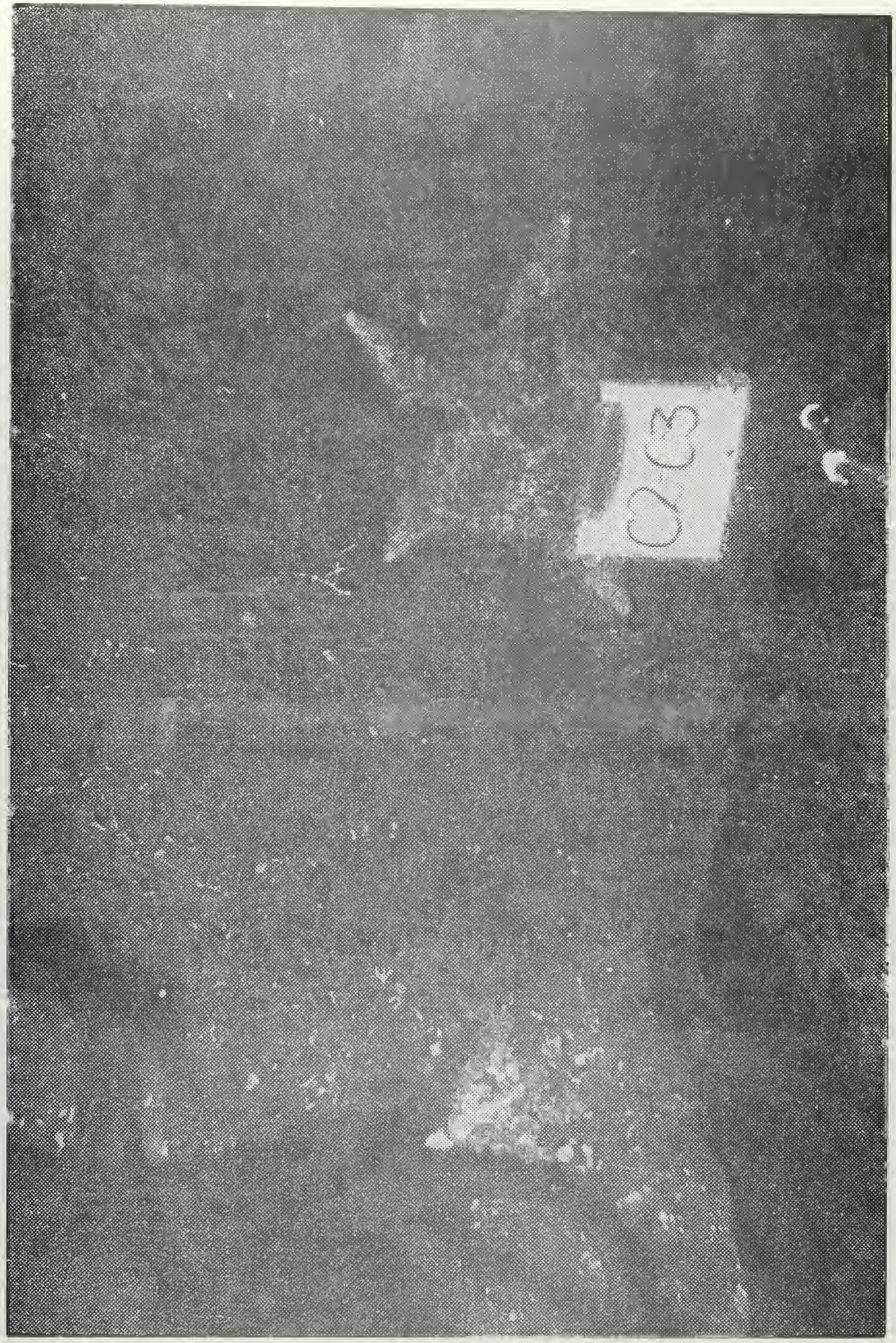


Figure 43. Subarea C2-C3

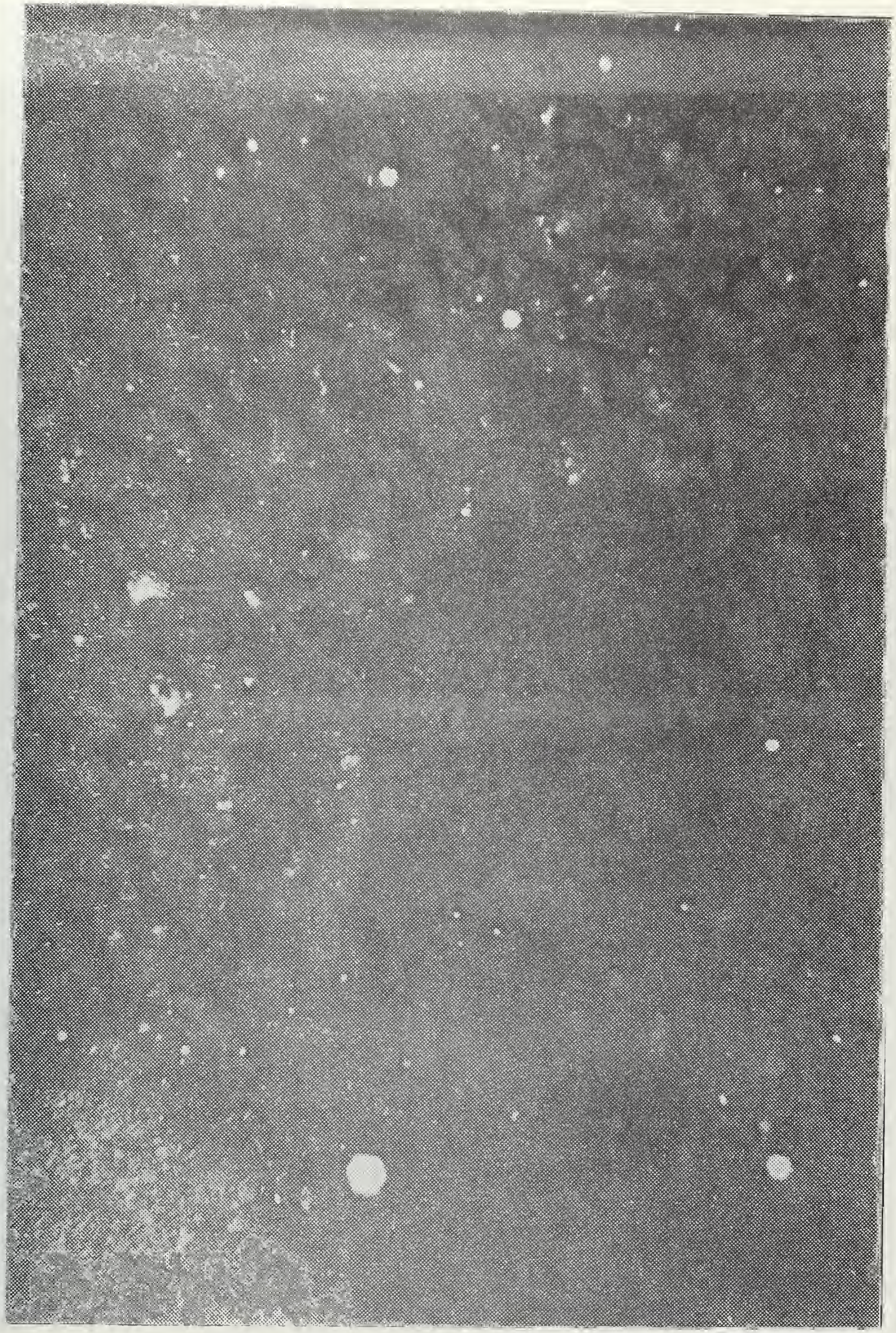


Figure 44. Subarea D2-A1

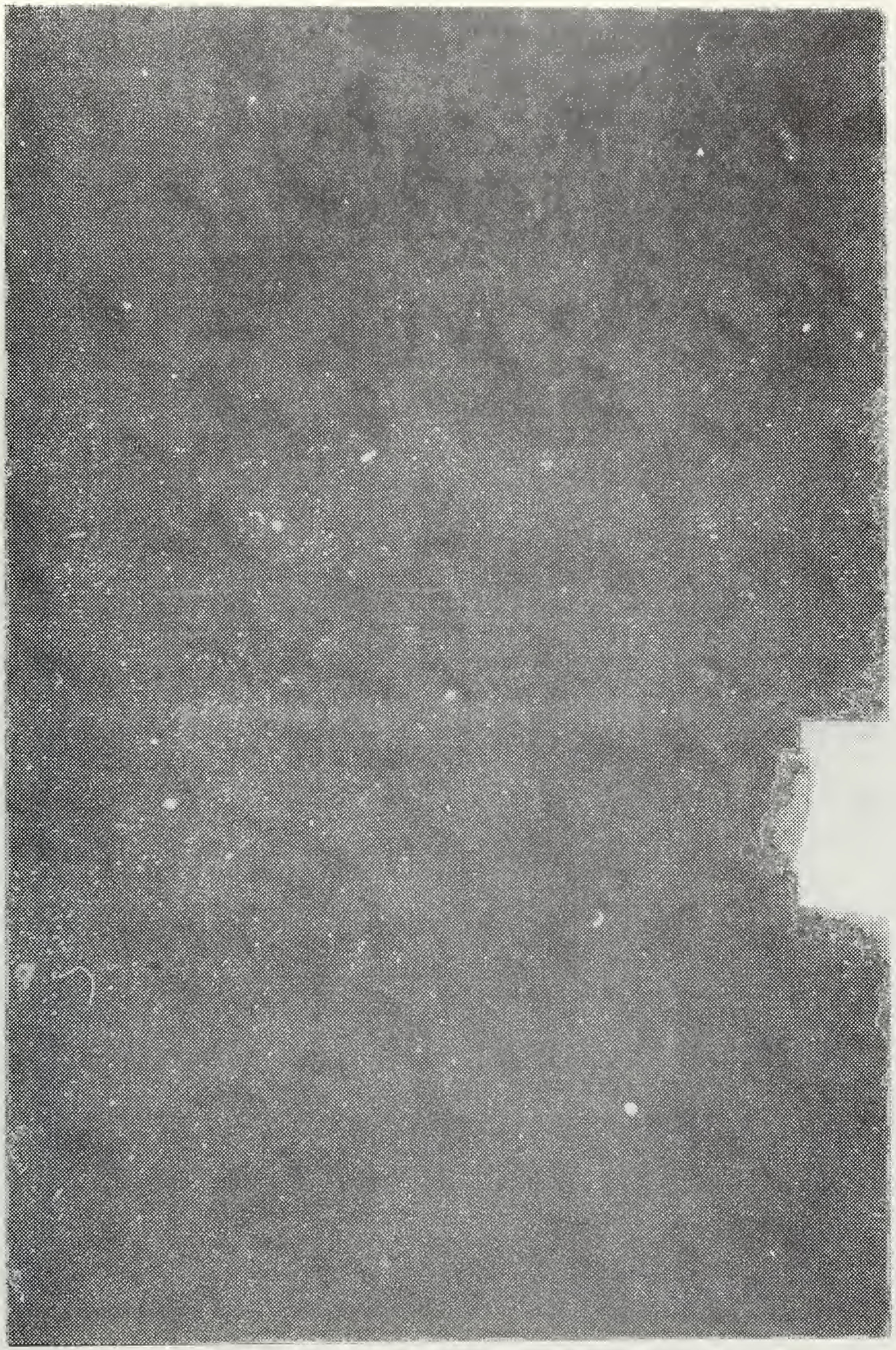


Figure 45. Subarea D2-A2

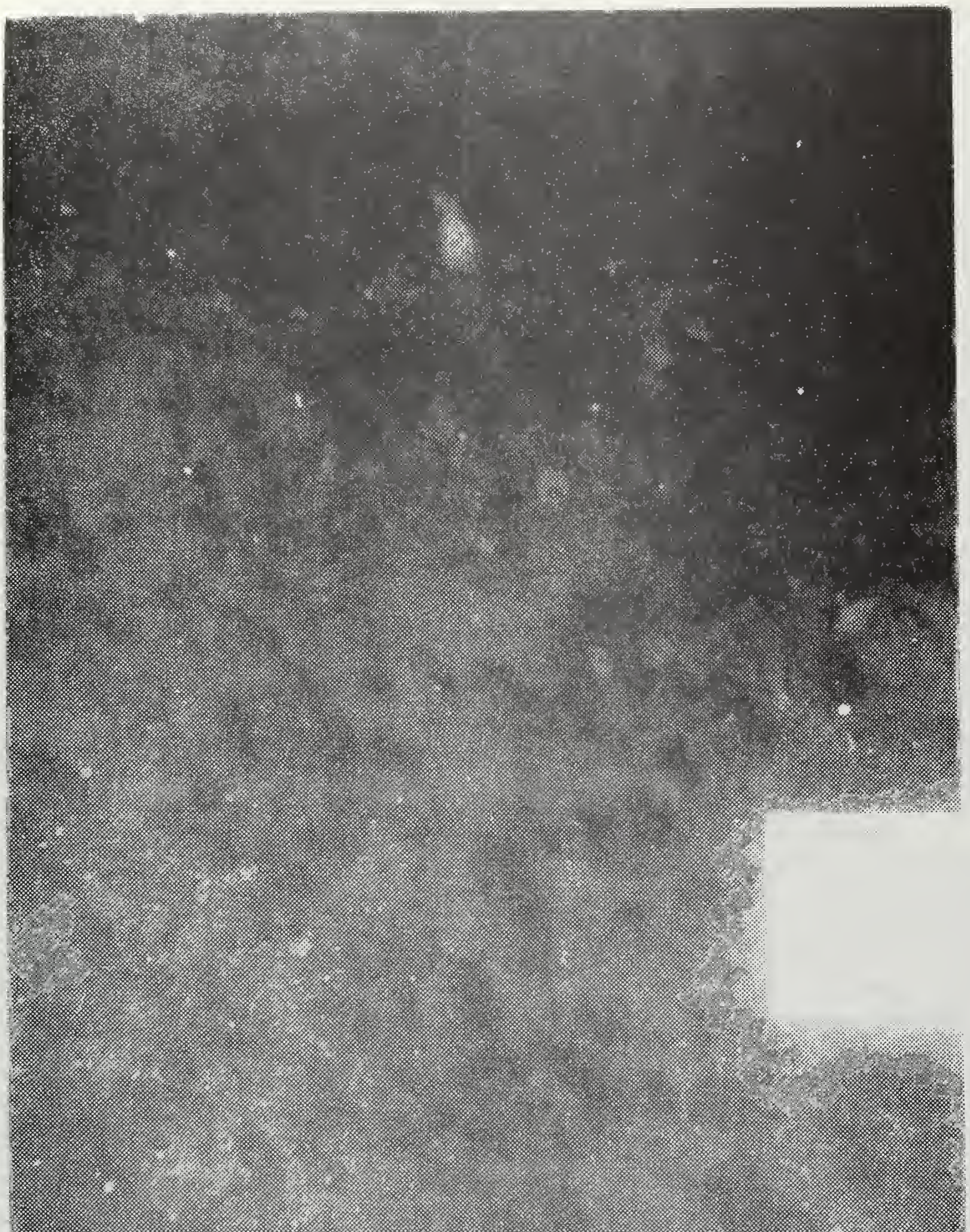


Figure 46. Subarea D2-A3

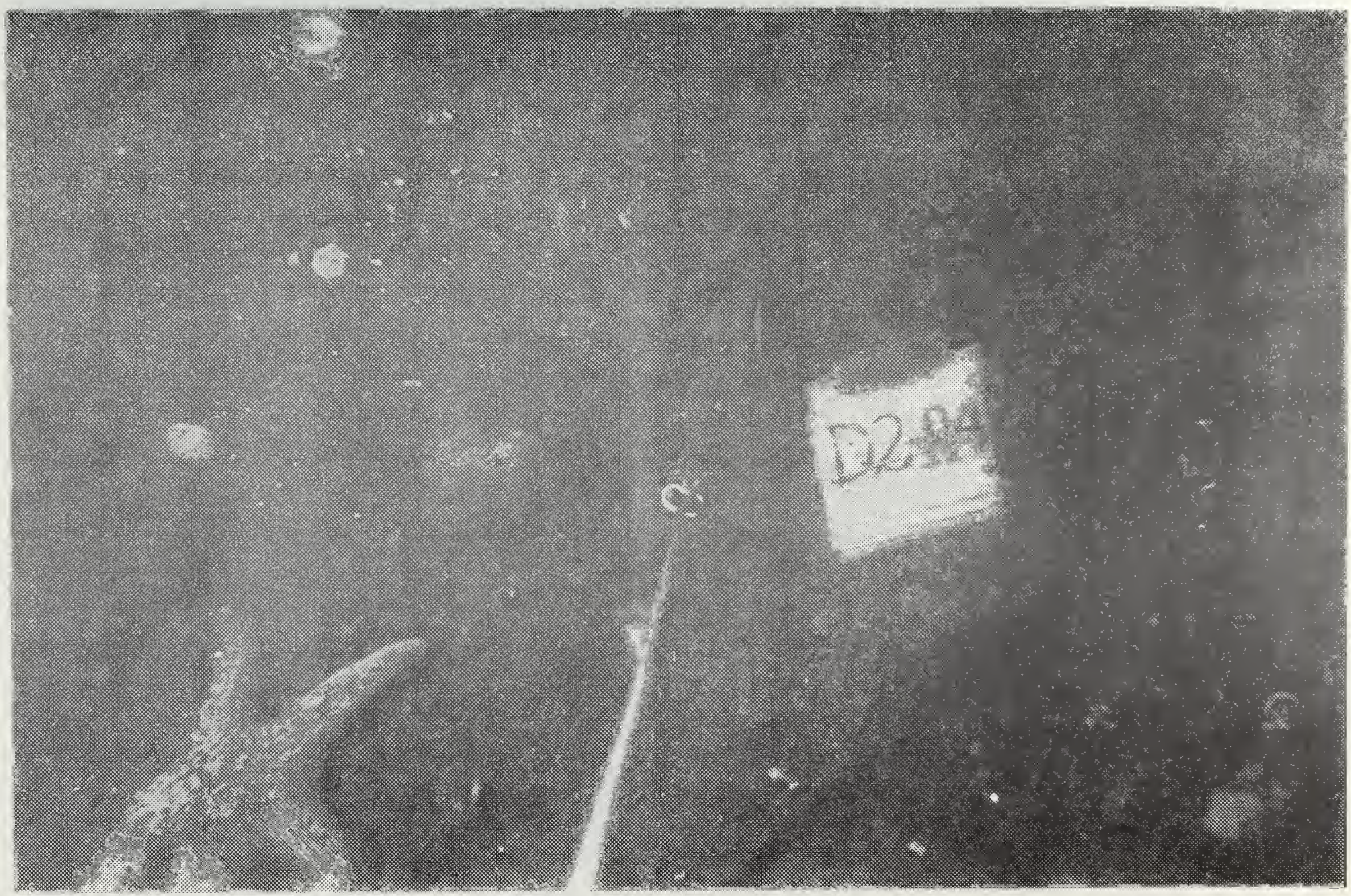


Figure 47. Subarea D2-A4

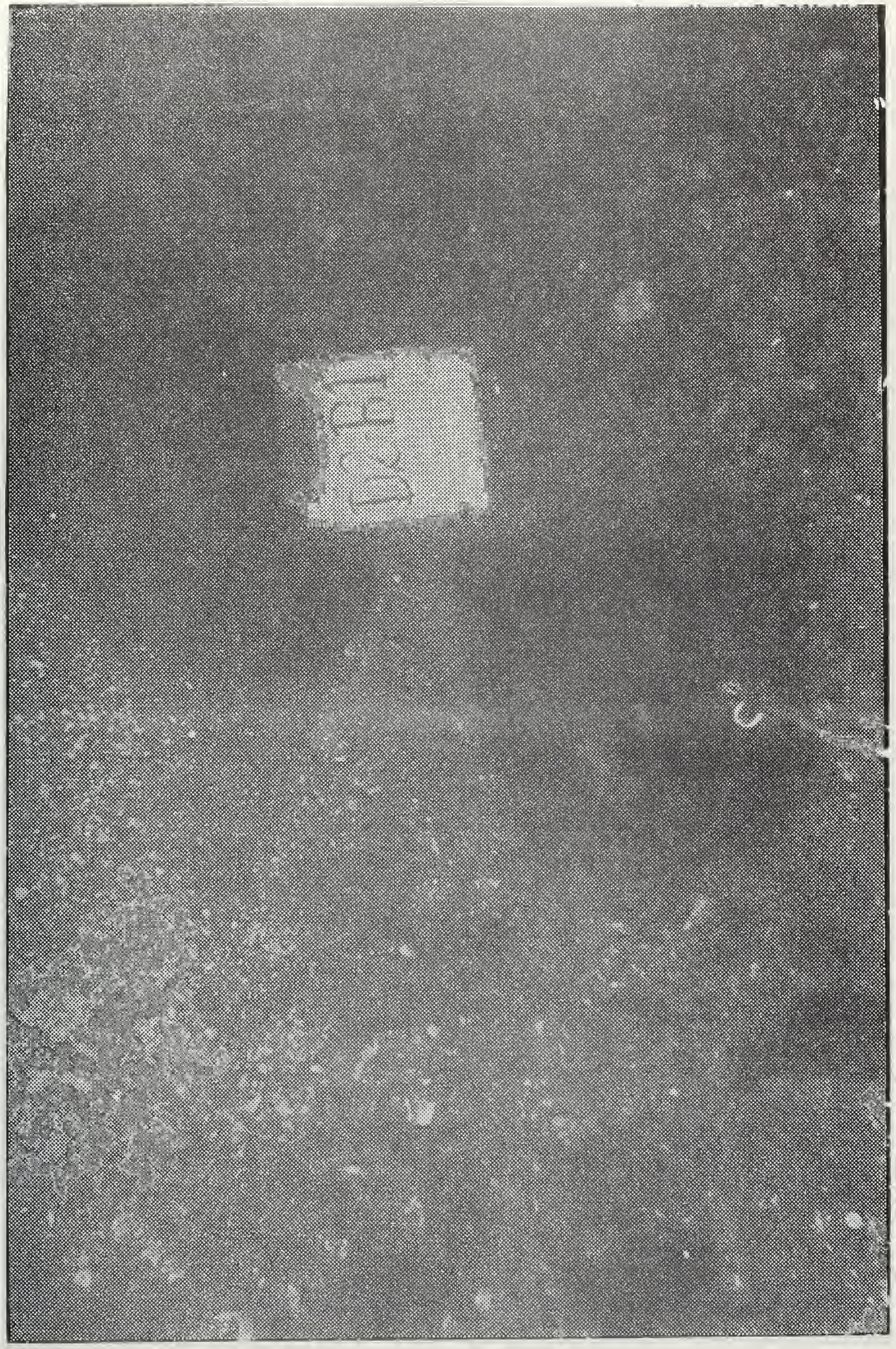


Figure 48. Subarea D2-B1

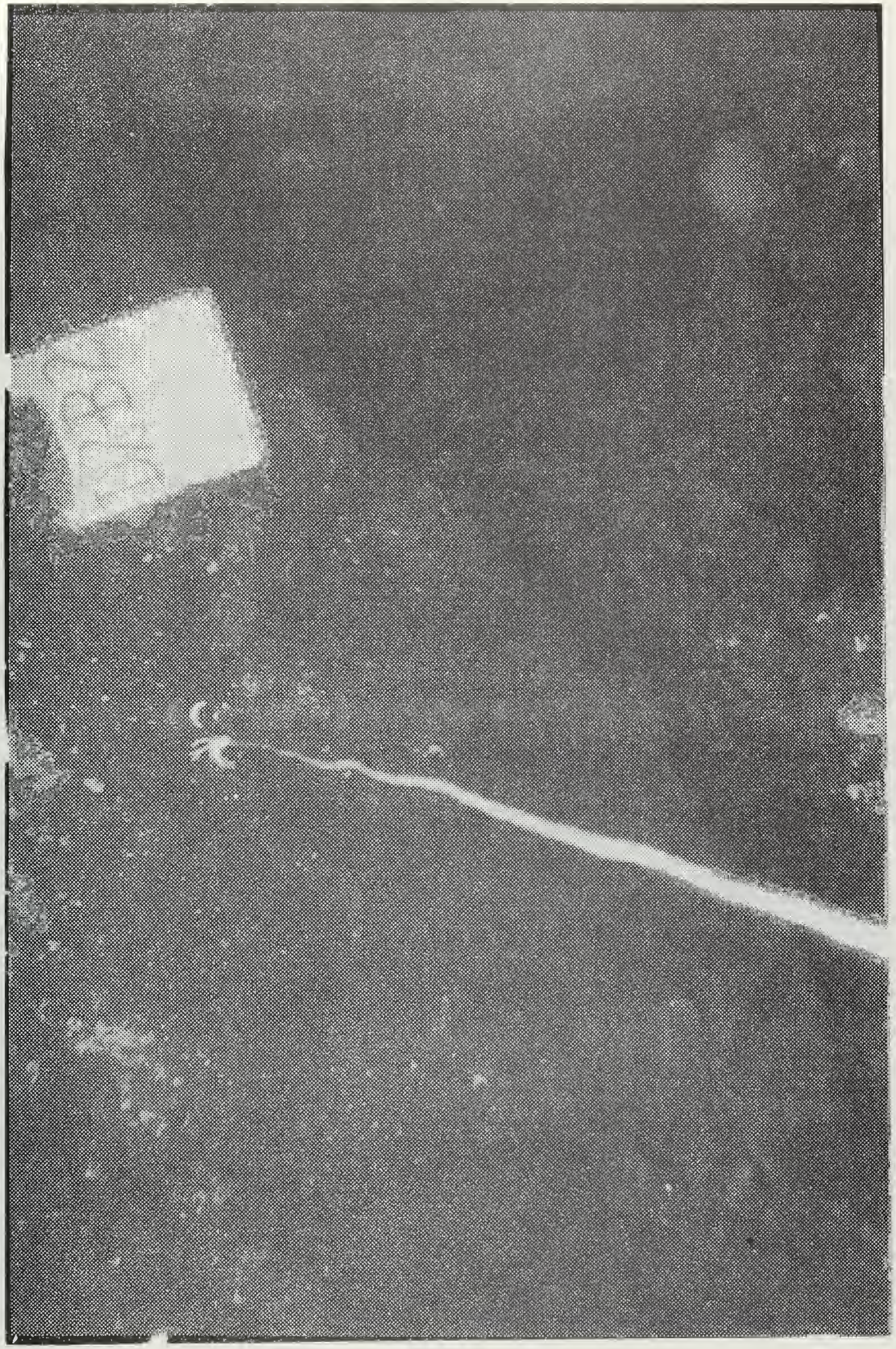


Figure 49. Subarea D2-B2

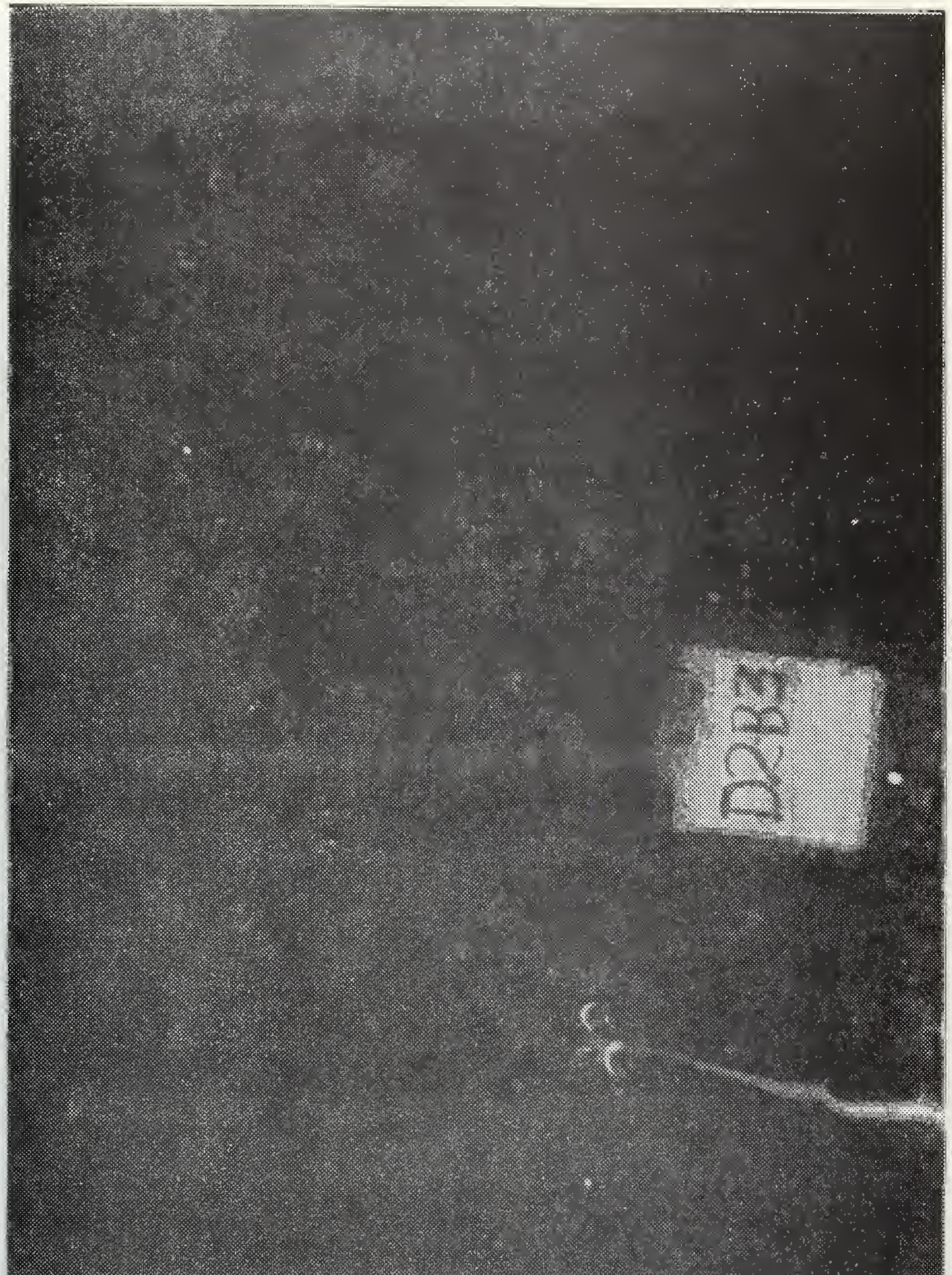


Figure 50. Subarea D2-B3

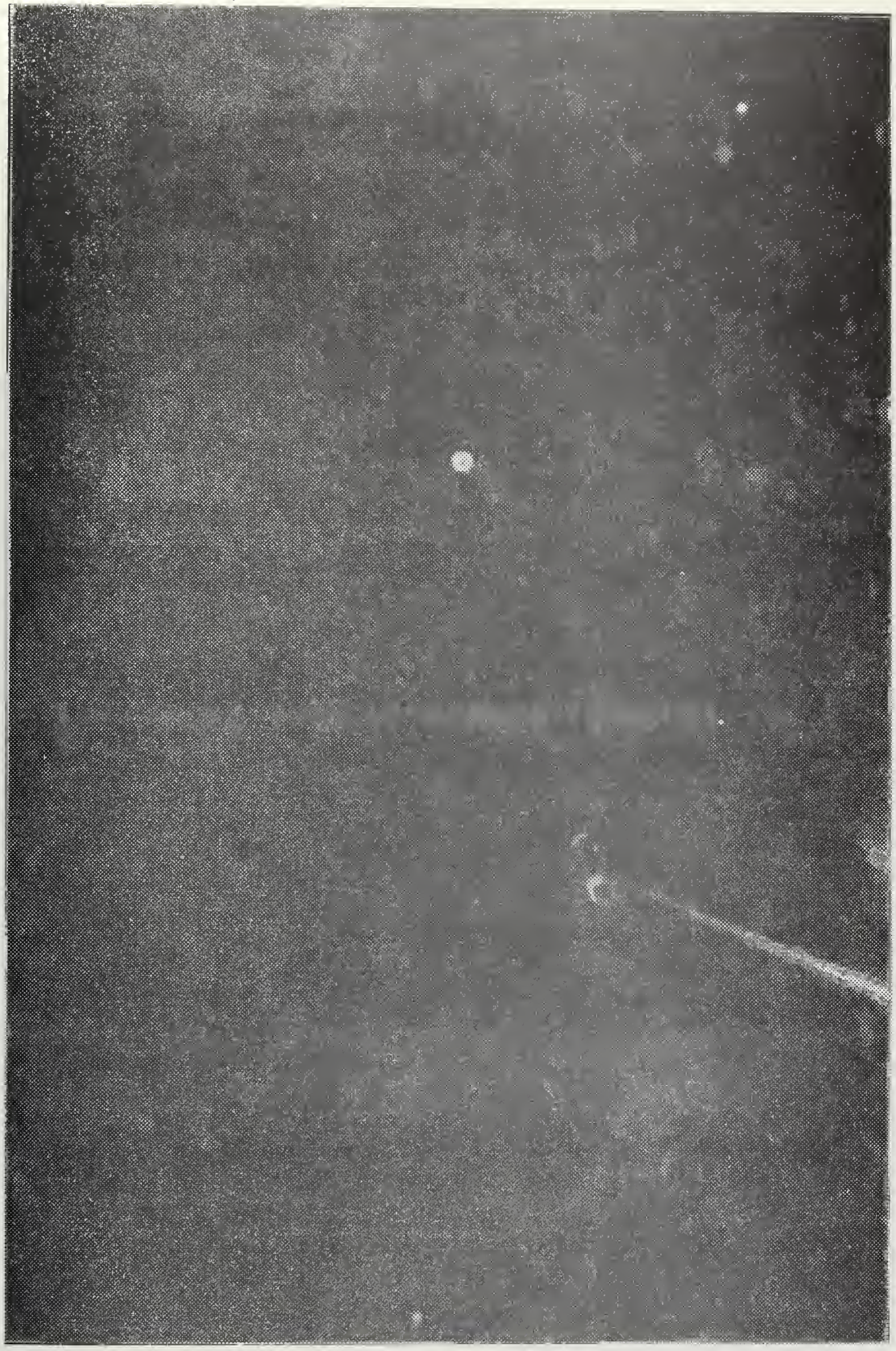


Figure 51. Subarea D2-B4

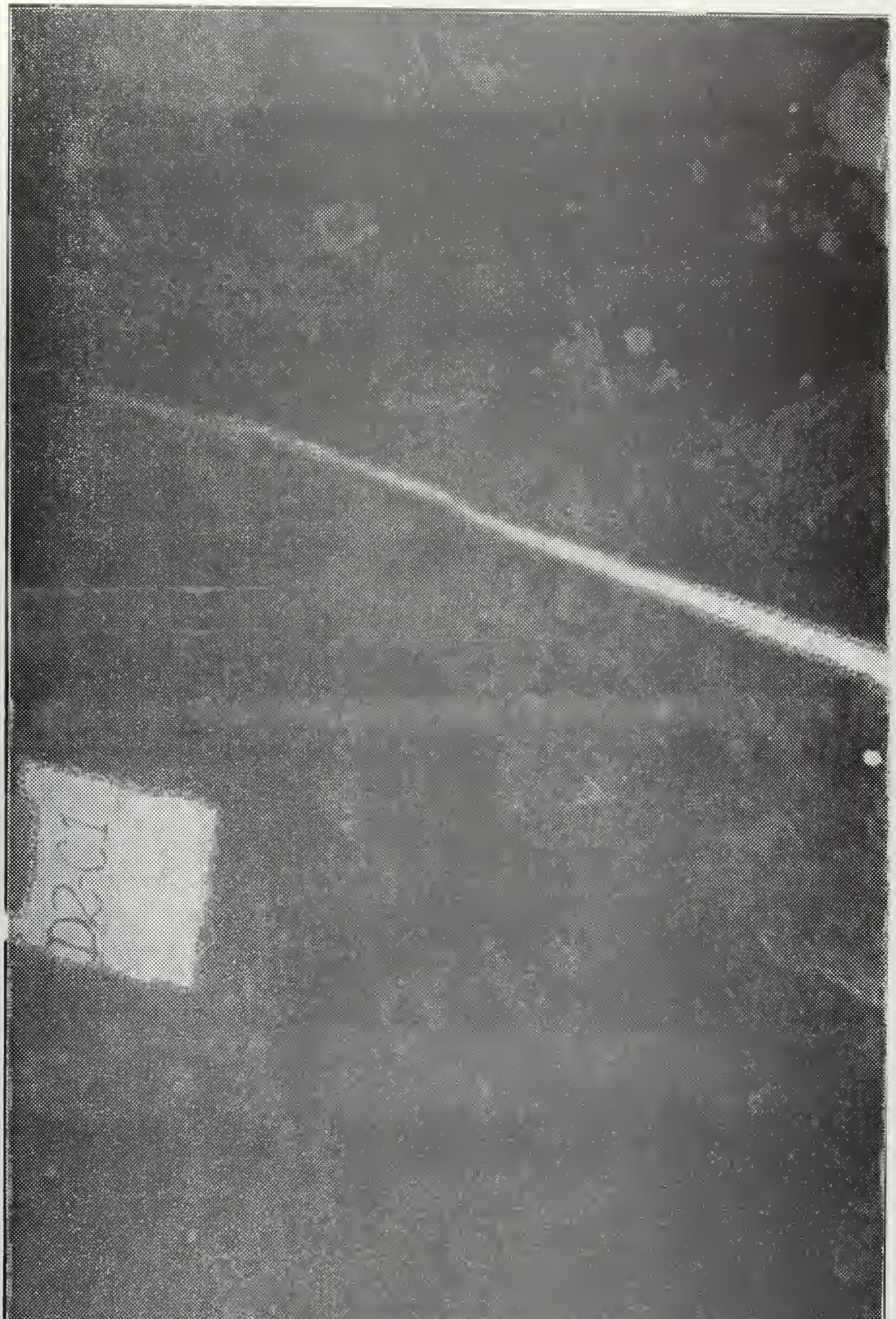


Figure 52. Subarea D2-C1

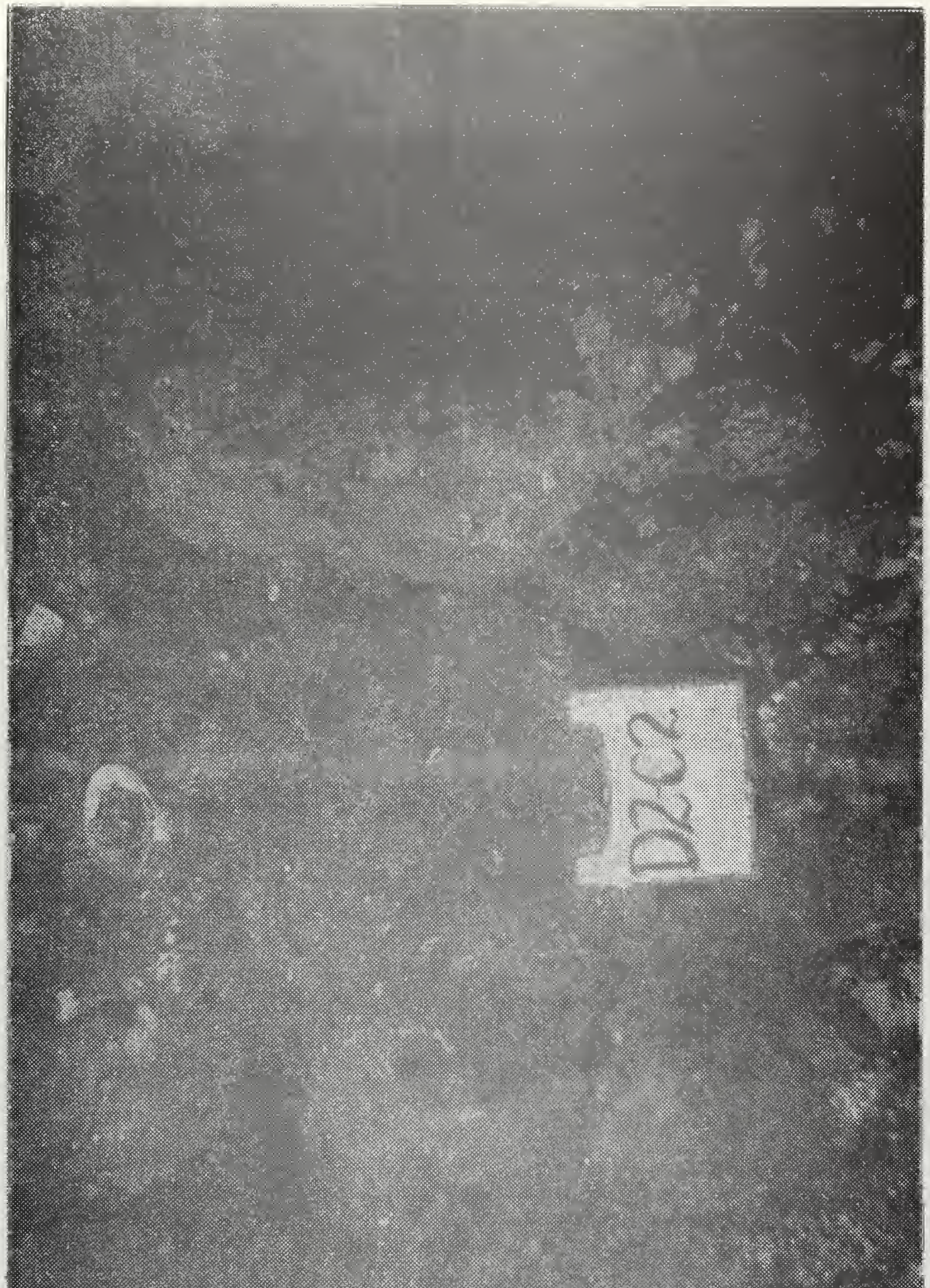


Figure 53. Subarea D2-C2

Figure 54. Subarea D2-C3

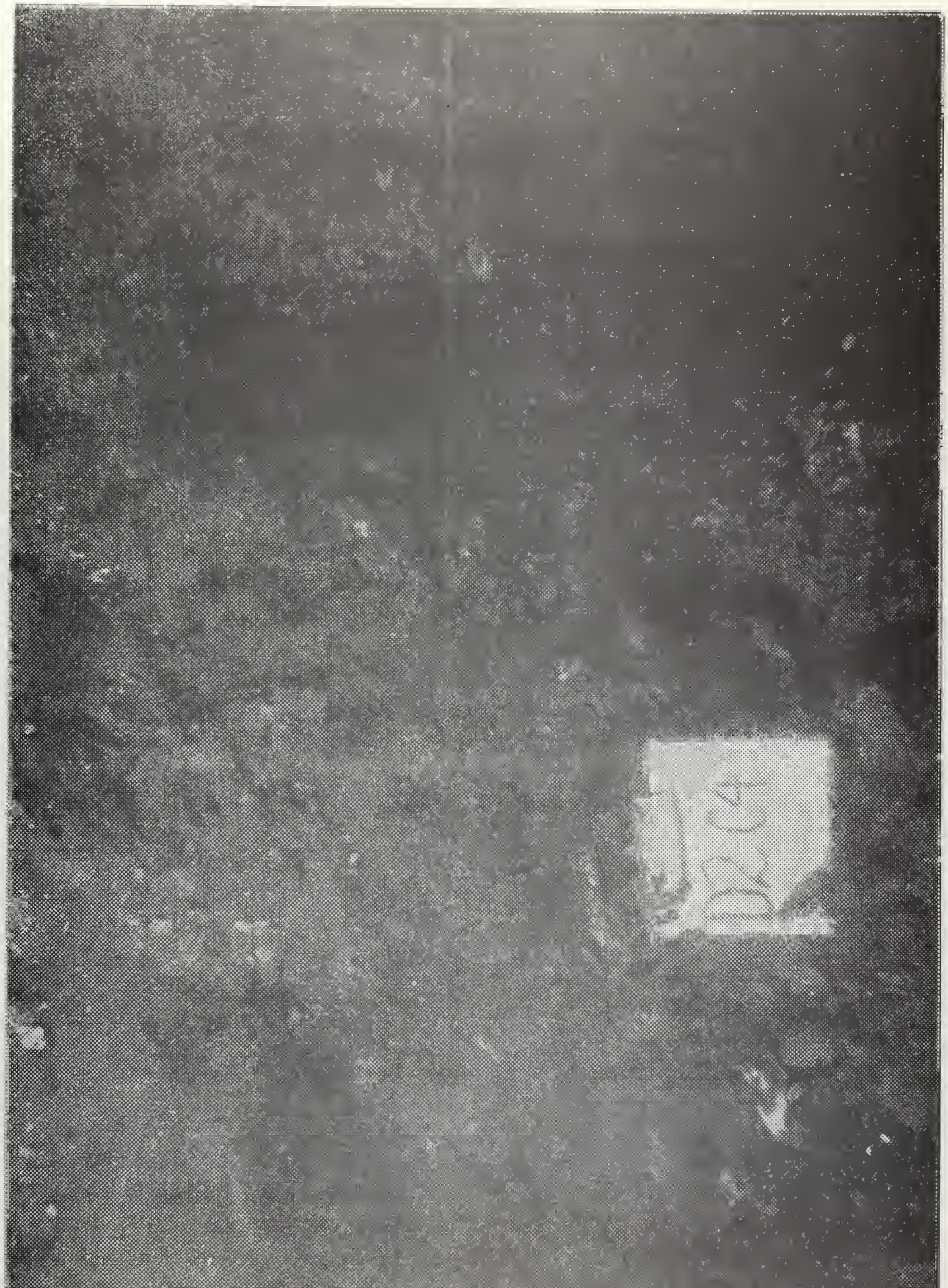


Figure 55. Subarea D2-C4

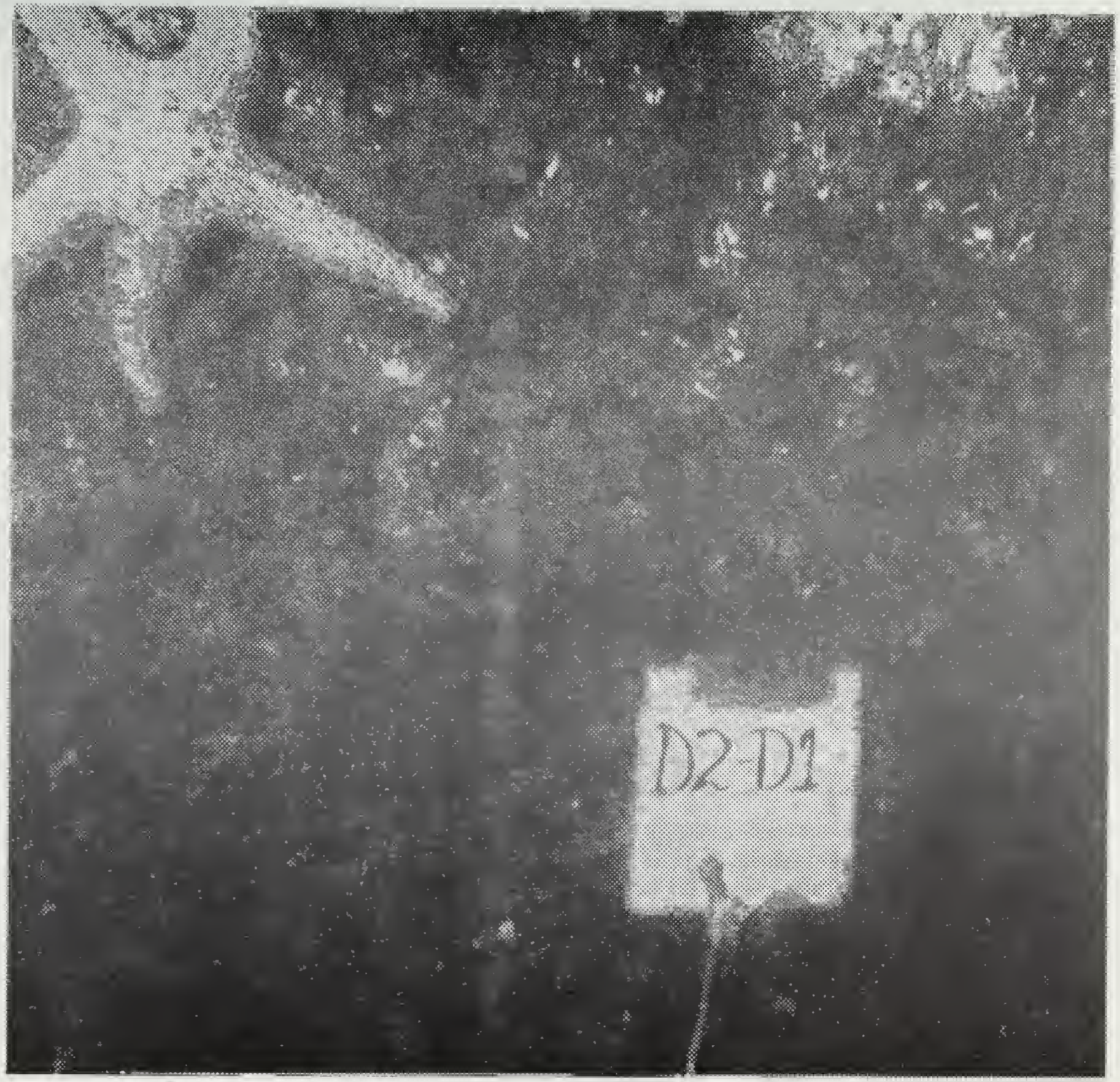


Figure 56. Subarea D2-D1

Figure 57. Subarea D2-D2

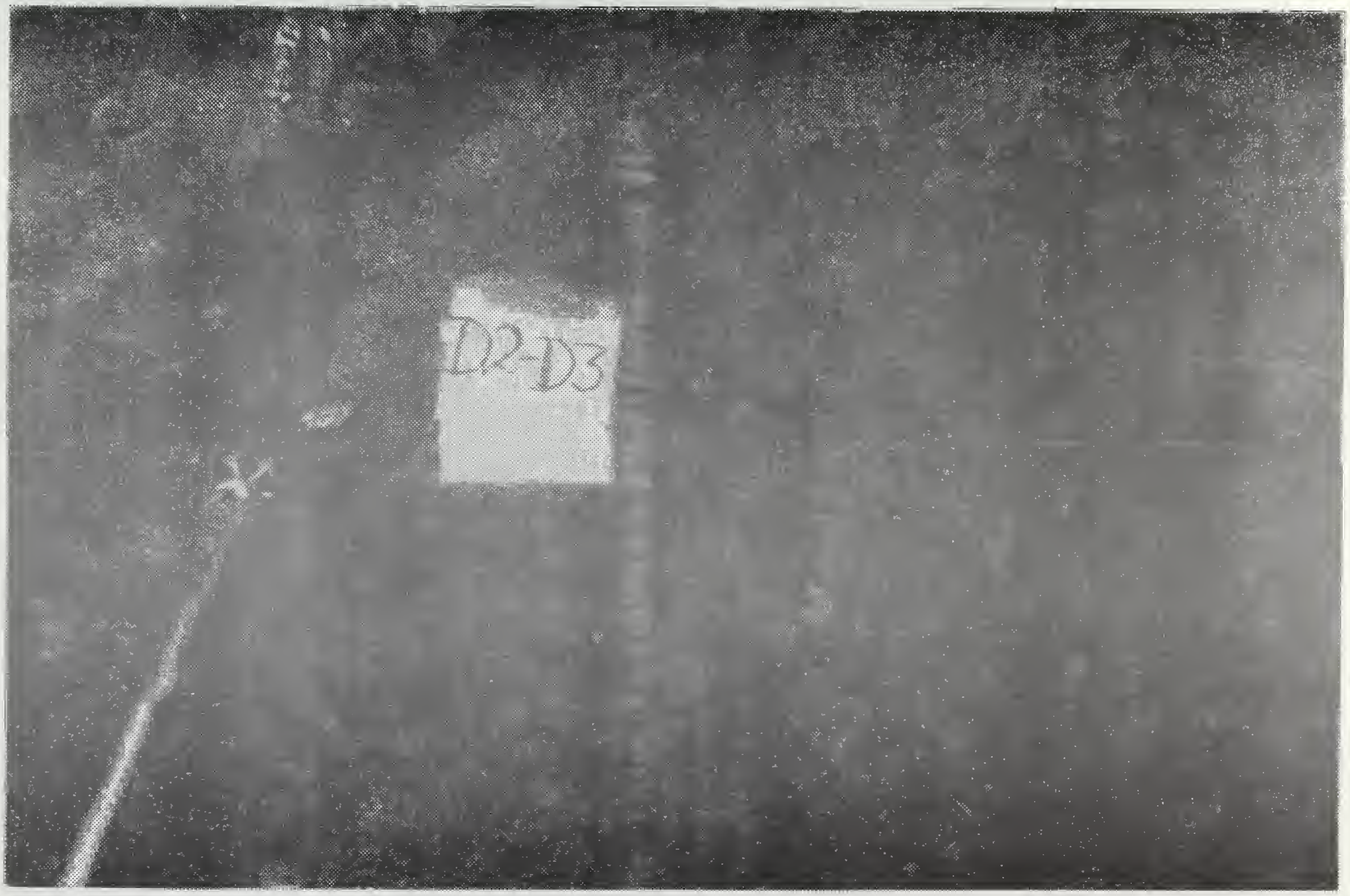


Figure 58. Subarea D2-D3

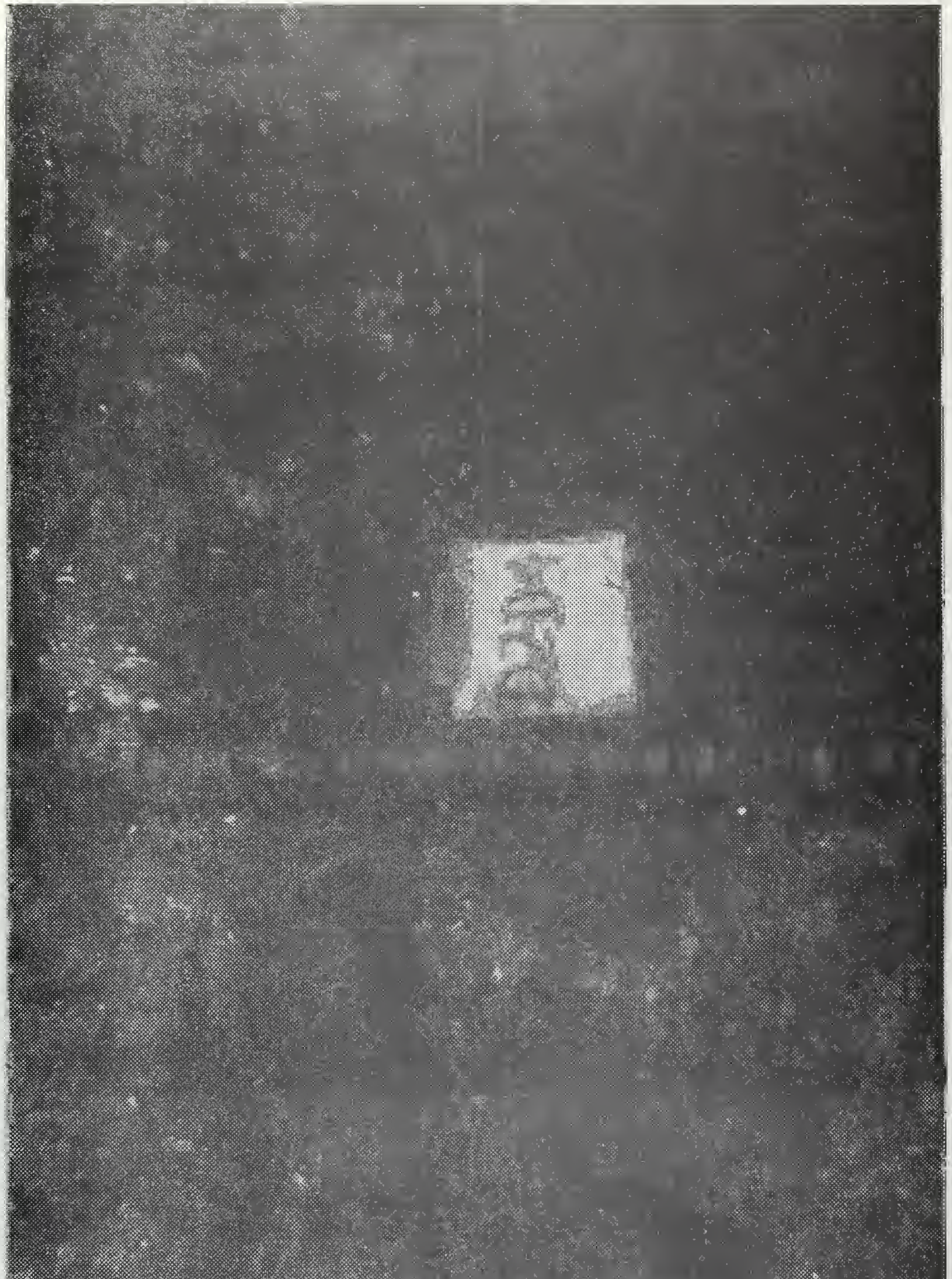


Figure 59. Subarea D2-D4

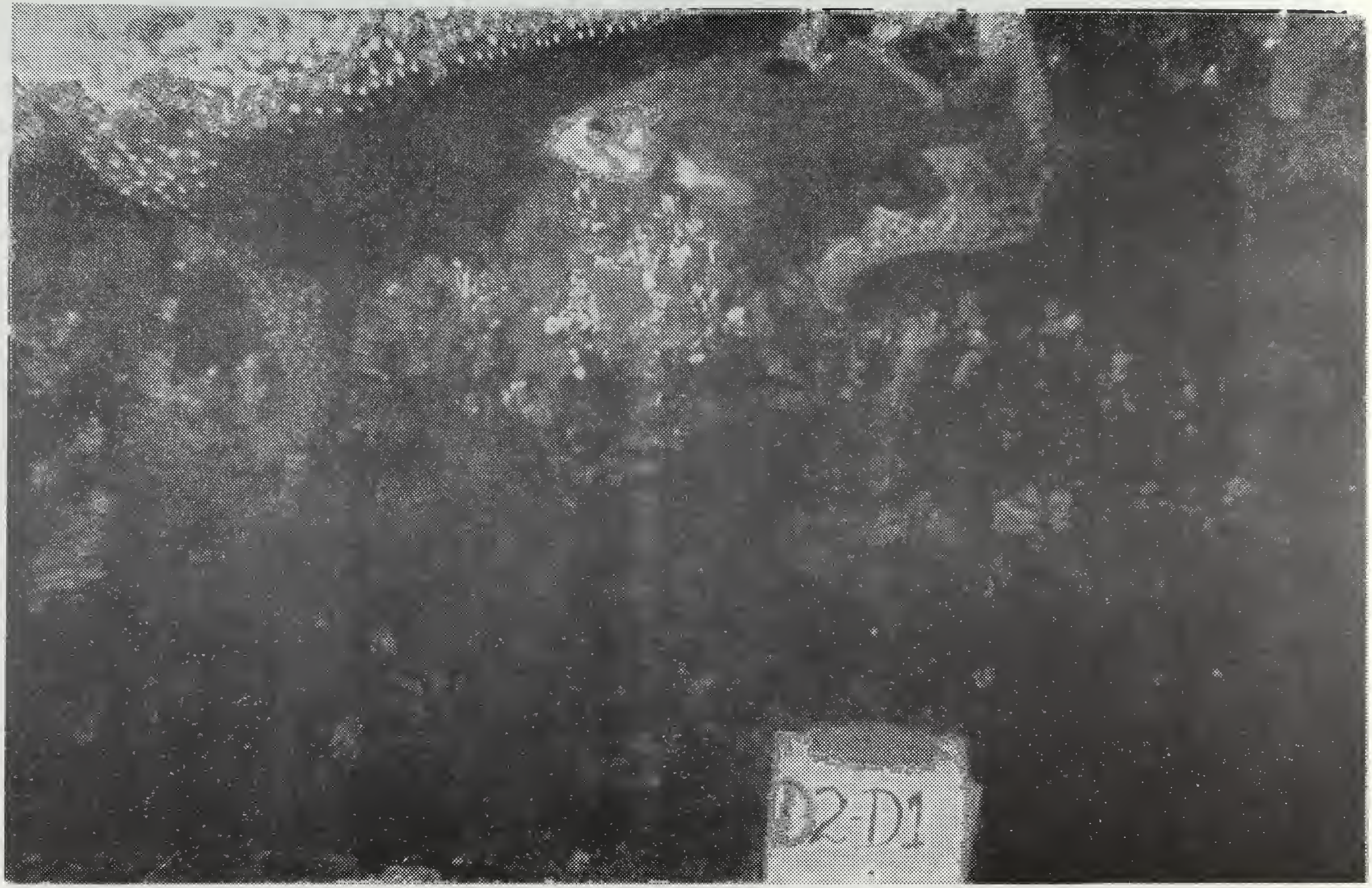


Figure 60. Ledge in Subarea D2-D1

Figure 61. Ledge in Subarea D2-D1

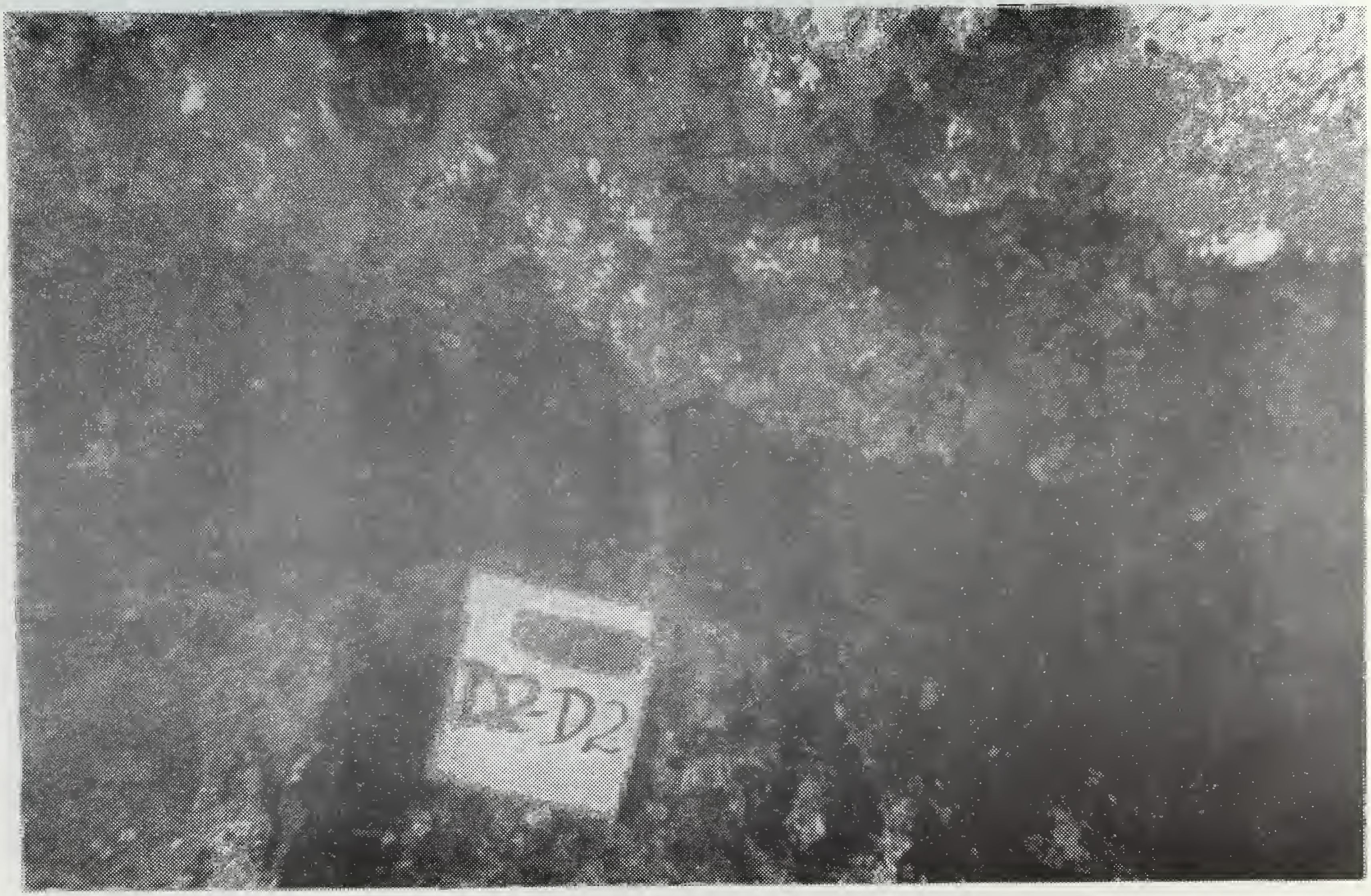


Figure 62. Ledge in Subarea D2-D2

Figure 63. Ledge in Subarea D2-D3

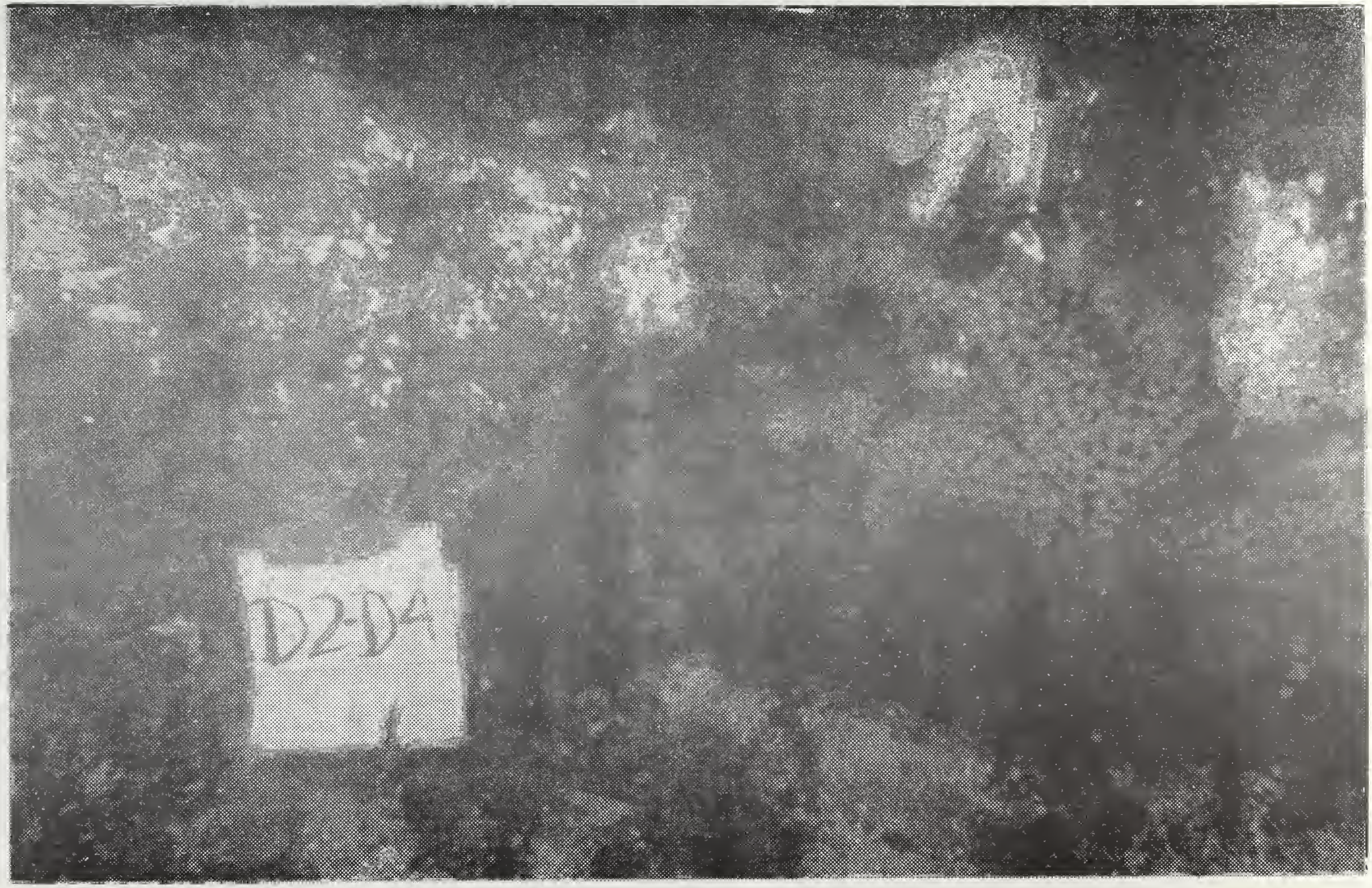


Figure 64. Ledge in Subarea D2-D4

APPENDIX C: POPULATION CENSUS DATA

The following key must be used to interpret the tables in this Appendix.

P	Present but not counted.
N	Numerous but not counted.
A	Abundant but not counted.
C	Colony.
%	Percentage of meter-square covered by organism.
~	Approximately.

Unfortunately time and other considerations did not permit inclusion of the large ledge in area D2 in the population survey. This ledge is so complex that a major study could be devoted to it alone. A few comments can be made based on a number of cursory examinations. It is inhabited by a vast population of the anemonies *Corynactis californica* and *Metridium exilis* which exist in large aggregations. On parts of the ledge, mostly near the rim, *Balanus crenatus* occurs in abundance. The middle and lower (undercut) regions are populated by a large number of the huge boring pholad *Chaceia ovoidea*. Here too, exist a number of tunicate species including *Eudistoma diaphanes* and a thick, whitish, encrusting form which is probably *Cystodytes* sp. At the base, several colonies of the Bryozoa *Thalamoporella californica* are present. One specimen of an unusual solitary ascidian, unidentified at the time of

writing, was also taken from this ledge. Numerous seastars, primarily *Pisaster brevispinus*, may be found combing the ledge in search of food.

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area C2- A1	A2	A3	B1	B2	B3	C1	C2	C3
PORIFERA:	P									
Leuconia heathi	P1				1					1
Leucosolenia eleanor	P2	P	P	P		P		P		P
Rhabdodermella nuttingi	P4									
Craniella sp.	P5						5			
Acarnus erithacus	P6									
Unidentified No. 1	P sp#1								1C	
Unidentified No. 2	P sp#2	~15%						3C		P
Unidentified No. 3	P sp#3									
Unidentified No. 4	P sp#4			P	P	P	~40%			
Unidentified No. 5	P sp#5	1C					1C	1C		P
Unidentified No. 6	P sp#6									
COELENTERATA:										
Hydrozoa:										
Abietinaria spp.	C1	P			5			4		
Plumularia spp.	C10	P	P		P			2C	1C	P
Anthozoa:										
Anthopleura elegantissima / *Anthopleura artemisia*	C3	4			2	1			3	2
Balanophyllia elegans	C4					1	1	7	3	5
Diadumene leucolena	C5		1							
Corynactis californica	C7			1						
Edwardsiella californica	C8	1	3	P			1		1	
Metridium exilis	C9		1				2		1	
Tealia coriacea	C11							1		1
Annelida:	An									
Cirriformia sp.	An1	97	16	18	50	12	47	53	~75	~60
Diopatra ornata	An2	3					24	2	5	3

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area C2								
		A1	A2	A3	B1	B2	B3	C1	C2	C3
Dodecaceria fistulicola	An3		P				3C			
Eudistylia polymorpha	An4									
Phyllochaetopterus prolifica	An5				4				4	3
Sabellaria cementarium	An6	P								
Serpula vermicularis	An8	5	1				2	1	1	
Thelepus sp.	An9									
Sipunculoidea:	S									
Dendrostomum dyscritum } *Dendrostomum pyroides* }	S 1	16	28	17	~ 25	8	~ 50	12	16	15
Phascolosoma agassizii	S 2		P							
ARTHROPODA:										
Crustacea:	Cr									
Cirripedia:										
Balanus crenatus	Cr 1				P				P	N
Balanus nubilis	Cr 2			2						
Decapoda:										
Cancer productus	Cr10						1j			
Lophopanopeus sp.	Cr11			1						
Loxorhynchus crispatus	Cr12					1			1	
Loxorhynchus grandis	Cr13									
Pugettia producta	Cr15				1					
Pugettia richii } *Pugettia gracilis* }	Cr16			1			2		2	
MOLLUSCA:	M									
Amphineura:										
Cryptochiton stelleri	M1						1			1
Mopalia ciliata	M2									1

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area C2- A1	A2	A3	B1	B2	B3	C1	C2	C3.
Mopalia muscosa	M3									
Placiphorella velata	M4	2	1	1	1		2	2	1	1
Tonicella lineata	M5									
Pelecypoda:										
Chaccia ovoidea	M6	2					1			
Hiatclla arctica	M7		P							
Hinnites multirugosus	M8						1		1	
Lithophaga plumula	M10		~20							
Parapholas californica	M11	20	5	2	3	3	4	5	9	4
Penitella sp.	M12	5	12	10		3	~30	10	1	6
Penitella gabbi	M12g									
Pododesmus cepio	M13	1			1		1			
Sphenia pholadidea	M14						1		2	1
Gastropoda:										
Calliastoma canaliculatum	M16									
Calliastoma costatum	M17		1							
Ceratostoma foliatum	M18									
Crepidula adunca	M19		1							
Diodora aspera	M20									
Ocenebra sp.	M22									
Astraea gibberosa	M42									
Nudibranchia / Tectibranchia:										
Acteon punctocoelata	M25	3	P	1	1	2			1	
Aegires albopunctata	M26	1								
Aeolidia sp.	M27		1							
Archidoris montereyensis	M30						1			
Dendronotus albus	M33									

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area C2-								
		A1	A2	A3	B1	B2	B3	C1	C2	C3
Diaulula sandiegensis	M34	1			1					
Doriopsilla albopunctata	M35				1					
Hermissenda crassicornis	M37	4	P		1	2		P	P	
Laila cockerelli	M40			1						
Rostanga pulchra	M41									
ECHINODERMATA:	E									
Asteroidea:										
Henricia leviuscula	E5									
Leptasterias sp.	E6									
Pisaster brevispinus	E8					1				1
Pisaster giganteus	E9									
Pycnopodia helianthoides	E11								1	
Patiria miniata	E15					1		2		
Echinoidea:										
Srongylocentrotus pupuratus	E13									
Holothuroidea:										
Cucumaria piperata	E1		P	P			2		1	
Eupentacta quinquesemita	E3		P				2			
Cucumaria miniata	E7									
CHORDATA:										
Ascidiacea (Tunicata):	T									
Amaroucium solidum	T1						2C			
Clavelina huntsmani	T2		26	1					20	31
Cystodytes sp.	T3			P						
Family Didemnidae	T4									
Eudistoma sp.	T5		P	P	P	P				1C
Eudistoma diaphanes	T6	4C	P		1C		5C	16C		2

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area C2-								
		A1	A2	A3	B1	B2	B3	C1	C2	C3
Eudistoma molle	T7									
Styela montereyensis	T9						1		1	1
Styela gibbsii	T10		1				2			1
Cnemidocarpa finmarkiensis	T11						1			
Boltenia villosa	T12									
Pyura haustor	T14									
Vertebrata:	V									
Neoclinus uninotatus	V1									
ALGAE:	A1									
Rhodophyta:										
Bossiella sp. (mostly *B. orbigniana*)	A1 2	P	N	N	N	N	P	P	P	N
Calliarthron sp.	A1 3	P	P	P	P	N		P	P	
Callophyllis sp.	A1 4	5								
Corallina chilensis	A1 5			4		6	P	P		
Plocamium coccineum	A1 9				P		P	P		
Lithophyllum	A1 10	P	~4%	~25%	P	P	P	P	P	P
Lithothrix aspergillum	A1 11									
Phodymenia sp.	A1 13									
Phaeophyta:										
Cystoseira osmundacea	A1 6	1			1		1			
Desmarestia herbacea	A1 7									
Dictyoneuropsis reticulata	A1 8			3	1				2	
Macrocystis pyrifera	A1 12				1		1			1

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2								
		A1	A2	A3	A4	B1	B2	B3	B4	
PORIFERA:	P									
Leuconia heathi	P1									
Leucosolenia eleanor	P2	P	P	P	P	P	P	P	P	
Rhabdodermella nuttingi	P4						5			
Craniella sp.	P5									
Acarnus erithacus	P6									
Unidentified No. 1	P sp#1									
Unidentified No. 2	P sp#2									
Unidentified No. 3	P sp#3				1C					
Unidentified No. 4	P sp#4									
Unidentified No. 5	P sp#5									
Unidentified No. 6	P sp#6									
COELENTERATA:										
Hydrozoa:										
Abietinaria spp.	C1		P	18			P	P	N	
Plumularia spp.	C10	P	P	P	1C		P	P	P	
Anthozoa:										
Anthopleura elegantissima } *Anthopleura artemisia*	C3		1	8	20	16	11	N	N	
Balanophyllia elegans	C4								P	
Diadumene leucolena	C5					1				
Corynactis californica	C7									
Edwardsiella californica	C8									
Metridium exilis	C9		P		10				P	
Tealia coriacea	C11									
Annelida:	An									
Cirriformia sp.	An1			2			14		~60	
Diopatra ornata	An2	~250	~1500	~1000	31		~200	~30	~40	

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2- A1	A2	A3	A4	B1	B2	B3	B4	
Dodecaceria fistulicola	An3						~15			
Eudistylia polymorpha	An4									
Phyllochaetopterus prolifica	An5						5		2	
Sabellaria cementarium	An6									
Serpula vermicularis	An8									
Thelepus sp.	An9						1			
Sipunculoidea:	S									
Dendrostomum dyscritum } Dendrostomum pyroides }	S1				P		2			
Phascolosoma agassizii	S2									
ARTHROPODA:										
Crustacea:	Cr									
Cirripedia:										
Balanus crenatus	Cr1	P				P	N	P		
Balanus nubilis	Cr2									
Decapoda:										
Cancer productus	Cr10									
Lophopanopeus sp.	Cr11									
Loxorhynchus crispatus	Cr12		1	P						
Loxorhynchus grandis	Cr13									
Pugettia producta	Cr15									
Pugettia richii } Pugettia gracilis }	Cr16									
MOLLUSCA:	M									
Amphineura:										
Cryptochiton stelleri	M1	1							1	
Mopalia ciliata	M2									

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2-								
		A1	A2	A3	A4	B1	B2	B3	B4	
Mopalia muscosa	M3									
Placiphorella velata	M4									
Tonicella lineata	M5									
Pelecypoda:										
Chaceia ovoidea	M6		1				3	1	4	
Hiatella arctica	M7									
Hinnites multirugosus	M8									
Lithophaga plumula	M10									
Parapholas californica	M11			8	~50		10	N	N	
Penitella sp.	M12									
Penitella gabbi	M12g		2	4	3	2	6	3	1	
Pododesmus cepio	M13									
Sphenia pholadidea	M14									
Gastropoda:										
Calliastoma canaliculatum	M16									
Calliastoma costatum	M17									
Ceratostoma foliatum	M18								1	
Crepidula adunca	M19									
Diodora aspera	M20									
Ocenebra sp.	M22									
Astraea gibberosa	M42									
Nudibranchia / Tectibranchia:										
Acteon punctocoelata	M25				2					
Aegires albopunctata	M26	2	P							
Aeolidia sp.	M27									
Archidoris montereyensis	M30									
Dendronotus albus	M33									

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2- A1	A2	A3	A4	B1	B2	B3	B4	
Diaulula sandiegensis	M34									
Doriopsilla albopunctata	M35									
Hermissenda crassicornis	M37									
Laila cockerelli	M40									
Rostanga pulchra	M41									
ECHINODERMATA:	E									
Asteroidea:										
Henricia leviuscula	E5									
Leptasterias sp.	E6								1	
Pisaster brevispinus	E8			1		1	1			
Pisaster giganteus	E9									
Pycnopodia helianthoides	E11									
Patiria miniata	E15						1			
Echinoidea:										
Srongylocentrotus pupuratus	E13									
Holothuroidea:										
Cucumaria piperata	E1									
Eupentacta quinquesemita	E3									
Cucumaria miniata	E7									
CHORDATA:										
Ascidiacea (Tunicata):	T									
Amaroucium solidum	T1									
Clavelina huntsmani	T2		P	P	22		2	P	6C	
Cystodytes sp.	T3									
Family Didemnidae	T4									
Eudistoma sp.	T5								P	
Eudistoma diaphanes	T6				P				3	

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2-								
		A1	A2	A3	A4	B1	B2	B3	B4	
Eudistoma molle	T7				1C				1C	
Styela montereyensis	T9				1				1	
Styela gibbsii	T10			2					1	
Cnemidocarpa finmarkiensis	T11									
Boltenia villosa	T12								1	
Pyura haustor	T14								1	
Vertebrata:	V									
Neoclinus uninotatus	V1						1		1	
ALGAE:	Al									
Rhodophyta:										
Bossiella sp. (mostly B. orbigniana)	Al 2			2	P	1	P	P	P	
Calliarthron sp.	Al 3									
Callophyllis sp.	Al 4						P		P	
Corallina chilensis	Al 5									
Plocamium coccineum	Al 9	4	P	P	P	P	P			
Lithophyllum	Al 10					P				
Lithothrix aspergillum	Al 11									
Phodymenia sp.	Al 13		P		P					
Phaeophyta:										
Cystoseira osmundacea	Al 6						1			
Desmarestia herbacea	Al 7							1		
Dictyoneuropsis reticulata	Al 8				1				3	
Macrocystis pyrifera	Al 12									

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2-								
		C1	C2	C3	C4	D1	D2	D3	D4	
PORIFERA:	P									
Leuconia heathi	P1									
Leucosolenia eleanor	P2				P	N	N	N	N	
Rhabdodermella nuttingi	P4									
Craniella sp.	P5									
Acarnus erithacus	P6					1C			2C	
Unidentified No. 1	P sp#1									
Unidentified No. 2	P sp#2				1C		1C			
Unidentified No. 3	P sp#3									
Unidentified No. 4	P sp#4									
Unidentified No. 5	P sp#5			1C	1C	P	1C	P		
Unidentified No. 6	P sp#6			1C						
COELENTERATA:										
Hydrozoa:										
Abietinaria spp.	C1			P	~55	A	A	A	A	
Plumularia spp.	C10									
Anthozoa:										
Anthopleura elegantissima *Anthopleura artemisia*	C3	P		P	5		3	2	1	
Balanophyllia elegans	C4	8	3	4	9	15	P		P	
Diadumene leucolena	C5									
Corynactis californica	C7	~240				~450	A	A	A	
Edwardsiella californica	C8				1					
Metridium exilis	C9	P		P	10	N	N	N	P	
Tealia coriacea	C11									
Annelida:	An									
Cirriformia sp.	An1		22	~100	~85	23	P	P	12	
Diopatra ornata	An2		5	19	24		P		19	

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2-								
		C1	C2	C3	C4	D1	D2	D3	D4	
Dodecaceria fistulicola	An3					5C				
Eudistylia polymorpha	An4				1			1		
Phyllochaetopterus prolifica	An5			4			1			
Sabellaria cementarium	An6									
Serpula vermicularis	An8									
Thelepus sp.	An9									
Sipunculoidea:	S									
Dendrostomum dyscritum } Dendrostomum pyroides }	S1							7		
Phascolosoma agassizii	S2									
ARTHROPODA:										
Crustacea:	Cr									
Cirripedia:										
Balanus crenatus	Cr1	N	N	P		N	N	N	N	
Balanus nubilis	Cr2				1		1		1	
Decapoda:										
Cancer productus	Cr10									
Lophopanopeus sp.	Cr11									
Loxorhynchus crispatus	Cr12			1	1			1	1	
Loxorhynchus grandis	Cr13	1								
Pugettia producta	Cr15									
Pugettia richii } Pugettia gracilis }	Cr16				1					
MOLLUSCA:	M									
Amphineura:										
Cryptochiton stelleri	M1									
Mopalia ciliata	M2									

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2-								
		C1	C2	C3	C4	D1	D2	D3	D4	
Mopalia muscosa	M3						1			
Placiphorella velata	M4									
Tonicella lineata	M5							1		
Pelecypoda:										
Chaccia ovoidea	M6			6	7				1	
Hiatella arctica	M7					P	P	P	P	
Hinnites multirugosus	M8						1			
Lithophaga plumula	M10									
Parapholas californica	M11		9	N	N		1	1		
Penitella sp.	M12					P	P	P	P	
Penitella gabbi	M12g									
Pododesmus cepio	M13	1				1				
Sphenia pholadidea	M14						P			
Gastropoda:										
Calliastoma canaliculatum	M16	1								
Calliastoma costatum	M17					1				
Ceratostoma foliatum	M18			1	1			1		
Crepidula adunca	M19					1				
Diodora aspera	M20							1		
Ocenebra sp.	M22			1						
Astraea gibberosa	M42							1		
Nudibranchia / Tectibranchia:										
Acteon punctocoelata	M25			4						
Aegires albopunctata	M26									
Aeolidia sp.	M27									
Archidoris montereyensis	M30									
Dendronotus albus	M33			1					1	

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2								
		C1	C2	C3	C4	D1	D2	D3	D4	
Diaulula sandiegensis	M34									
Doriopsilla albopunctata	M35									
Hermissenda crassicornis	M37									
Laila cockerelli	M40									
Rostanga pulchra	M41						1			
ECHINODERMATA:	E									
Asteroidea:										
Henricia leviuscula	E5		1	1		1	2	1		
Leptasterias sp.	E6				1					
Pisaster brevispinus	E8	2	3	9		2	1	3		
Pisaster giganteus	E9		1			1				
Pycnopodia helianthoides	E11									
Patiria miniata	E15	1	1		1					
Echinoidea:										
Srongylocentrotus pupuratus	E13							2		
Holothuroidea:										
Cucumaria piperata	E1									
Eupentacta quinquesemita	E3									
Cucumaria miniata	E7			1						
CHORDATA:										
Ascidiacea (Tunicata):	T									
Amaroucium solidum	T1							1C		
Clavelina huntsmani	T2				47			55	32	
Cystodytes sp.	T3			1C						
Family Didemnidae	T4			1C						
Eudistoma sp.	T5		1C	2C					1C	
Eudistoma diaphanes	T6			P		P	P			

APPENDIX C: POPULATION CENSUS DATA

Scientific Name	map symbol	Area D2-								
		C1	C2	C3	C4	D1	D2	D3	D4	
Eudistoma molle	T7				1C		2C	1C	6C	
Styela montereyensis	T9				2	1	1		1	
Styela gibbsii	T10						1			
Cnemidocarpa finmarkiensis	T11									
Boltenia villosa	T12									
Pyura haustor	T14			2		3	2	5		
Vertebrata:										
Neoclinus uninotatus	V1					1	1			
ALGAE:	A1									
Rhodophyta:										
Bossiella sp. (mostly *B. orbigniana*)	A1 2			P	P	P	P	P	P	
Calliarthron sp.	A1 3					P	P	P	P	
Callophyllis sp.	A1 4			P	P	P	P	P		
Corallina chilensis	A1 5								1	
Plocamium coccineum	A1 9			P		P		P	P	
Lithophyllum	A1 10			P	P		P	P	P	
Lithothrix aspergillum	A1 11									
Phodymenia sp.	A1 13				1	P		P		
Phaeophyta:										
Cystoseira osmundacea	A1 6									
Desmarestia herbacea	A1 7									
Dictyoneuropsis reticulata	A1 8			2	1		1	2		
Macrocystis pyrifera	A1 12									

APPENDIX D: PHOTOGRAPHS OF SELECTED SPECIES

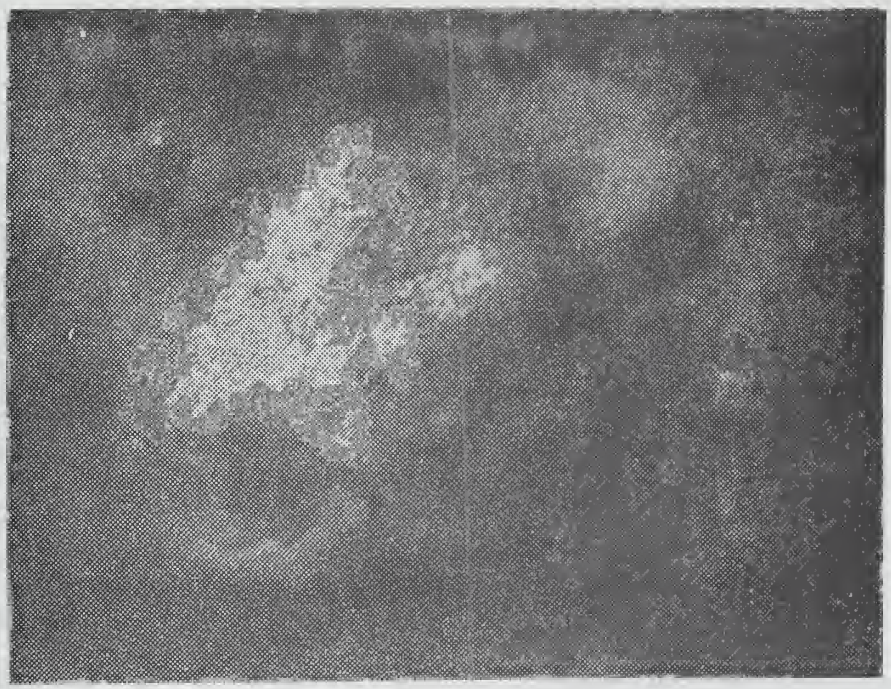
In this Appendix both individual and composite pictures (all taken *in situ*) are presented. Most of the organisms shown are described in section VIII of this thesis. When possible, degree of magnification is indicated.

Figure 65. Acarnus erithacus

Figure 66. Leucosolenia eleanor x 4

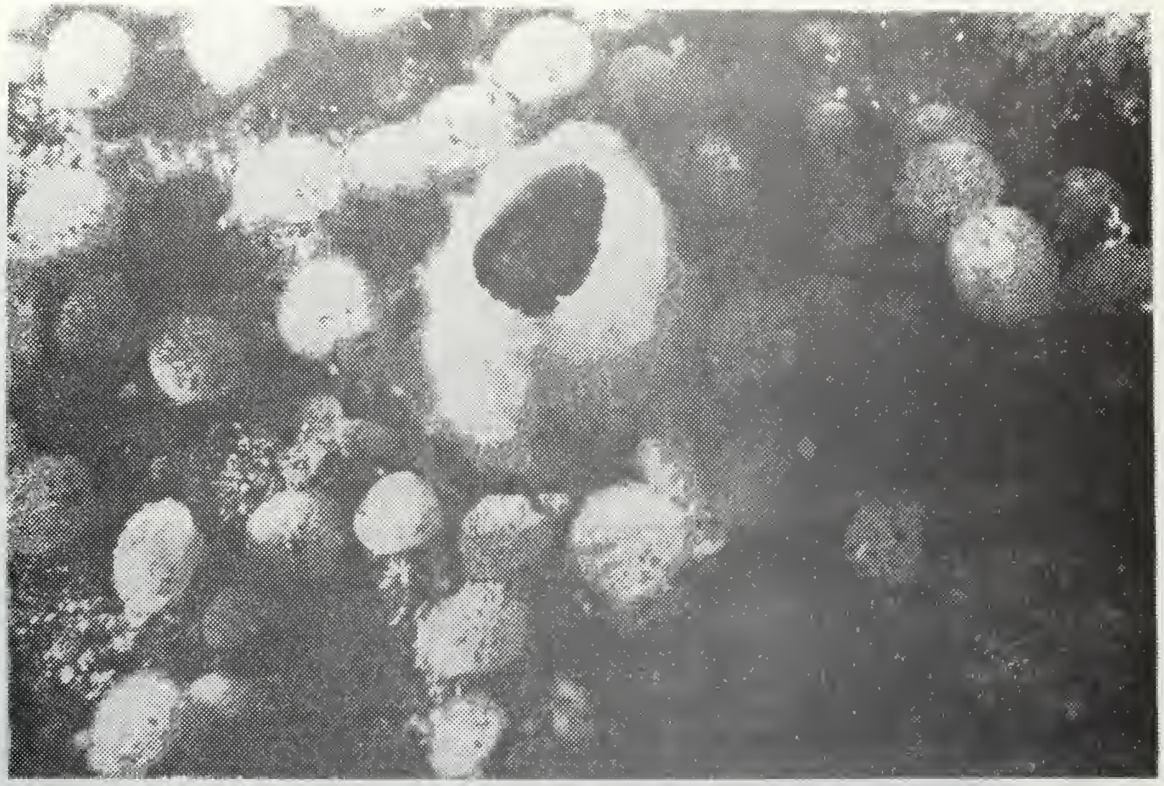
Figure 67. Polymastia pachymastia

x 4

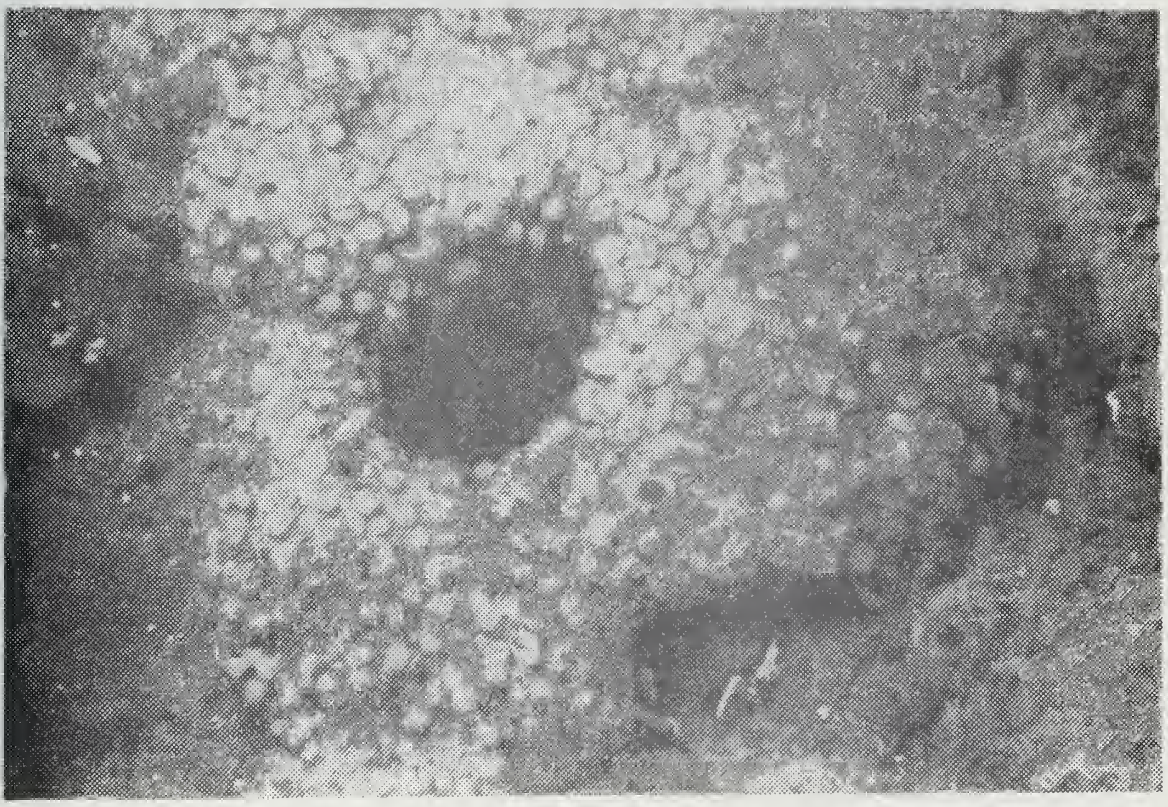


From 3 feet

Figure 68. Unidentified sponge (P sp.#2)

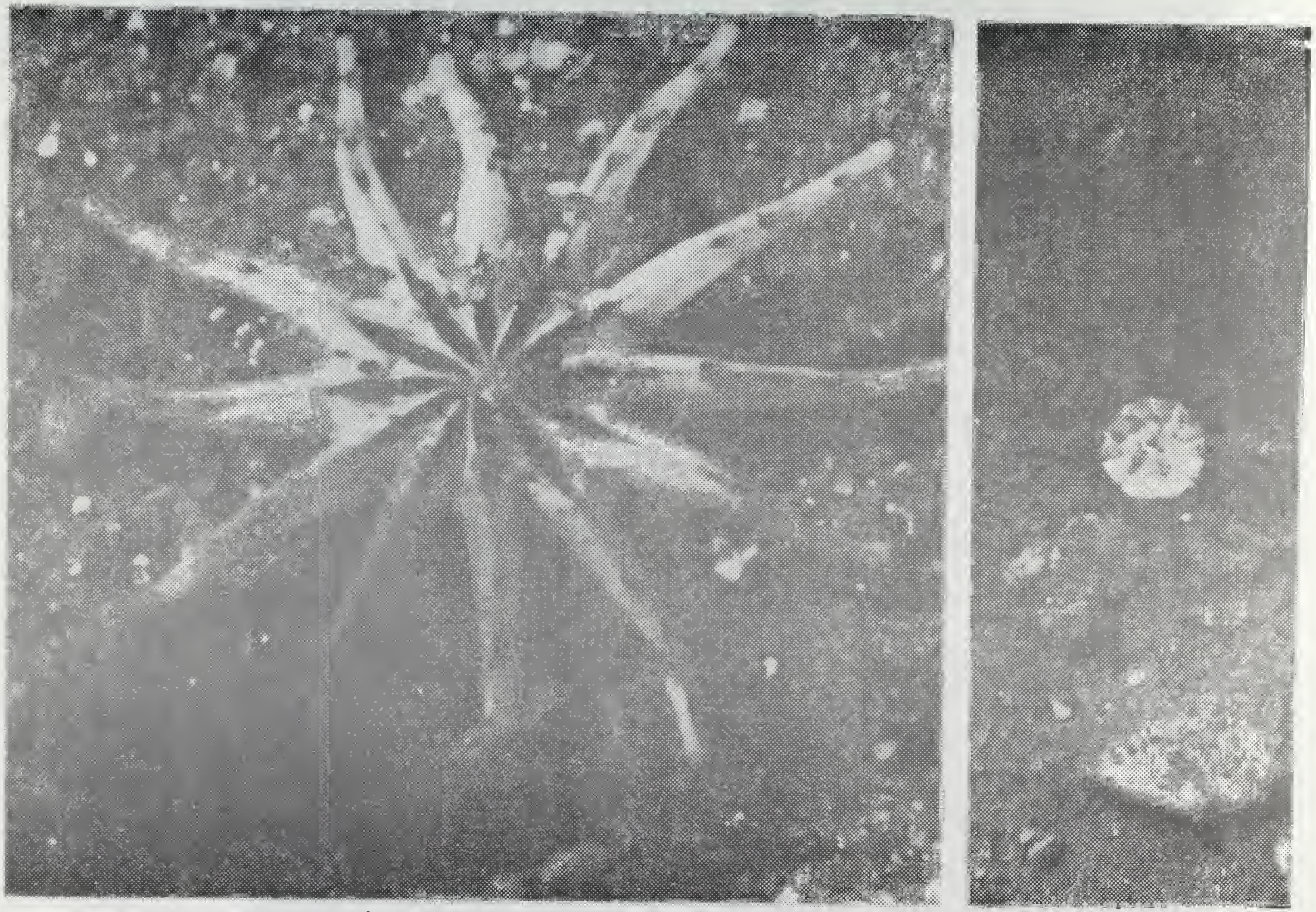


x 4



Life Size

Figure 69. Unidentified sponge (P sp.#3)



x 4 x 1.3

Figure 70. Burrowing anemonies tentatively identified as Edwardsiella californica

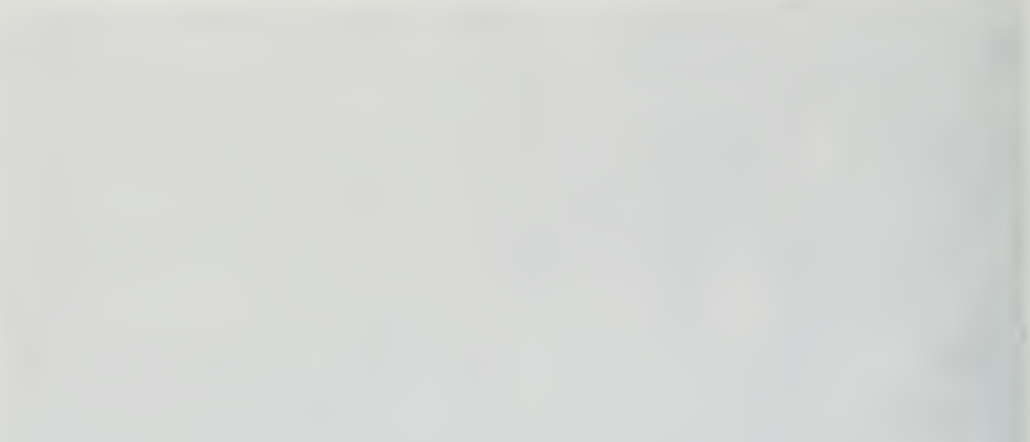


Figure 71. Tealia coriacea. Also shown is station corner bolt and polypropylene marking line (see section IV-C)

Figure 72. Tentacles of Dendrostomum dyscritum.

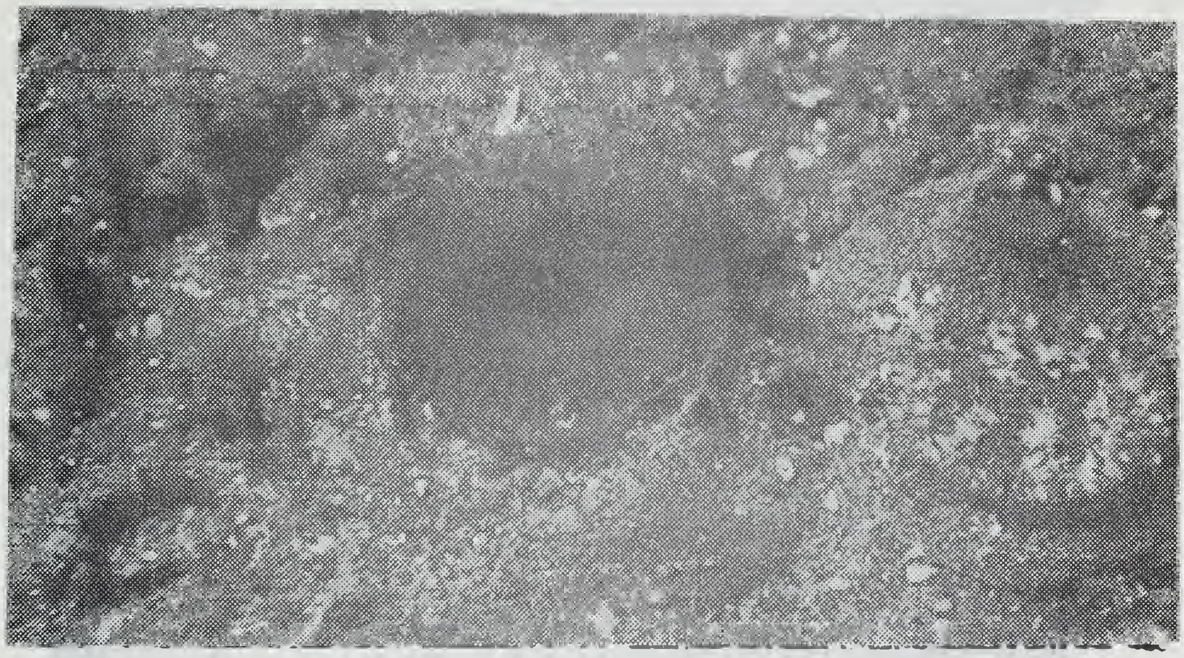


Figure 73. Unidentified annelid on left. Believed to be Myxicola sp. Siphons of Parapholas californica on right.

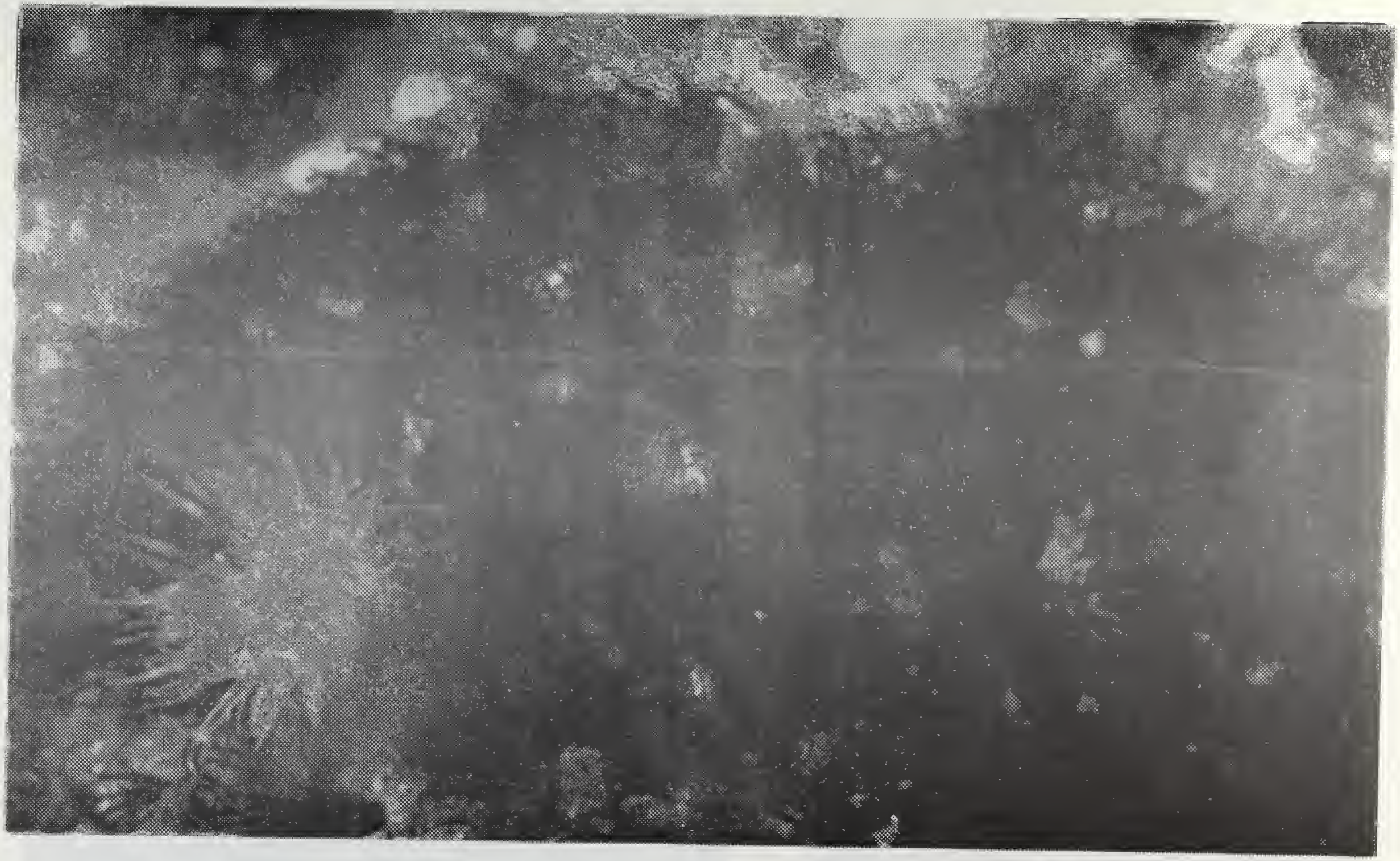


Figure 74. Metridium exilis on colony of Dodecaceria fistulicola (x 2)

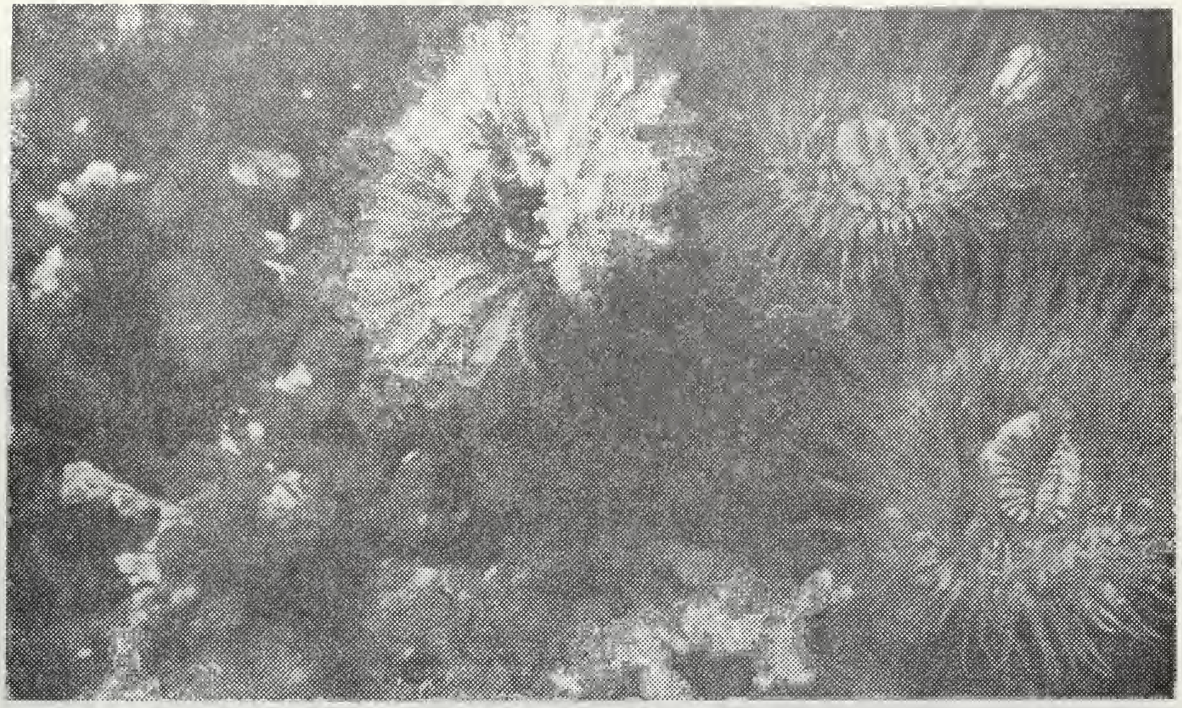


Figure 75. Eudistylia polymorpha, Metridium exilis (x 1.3)

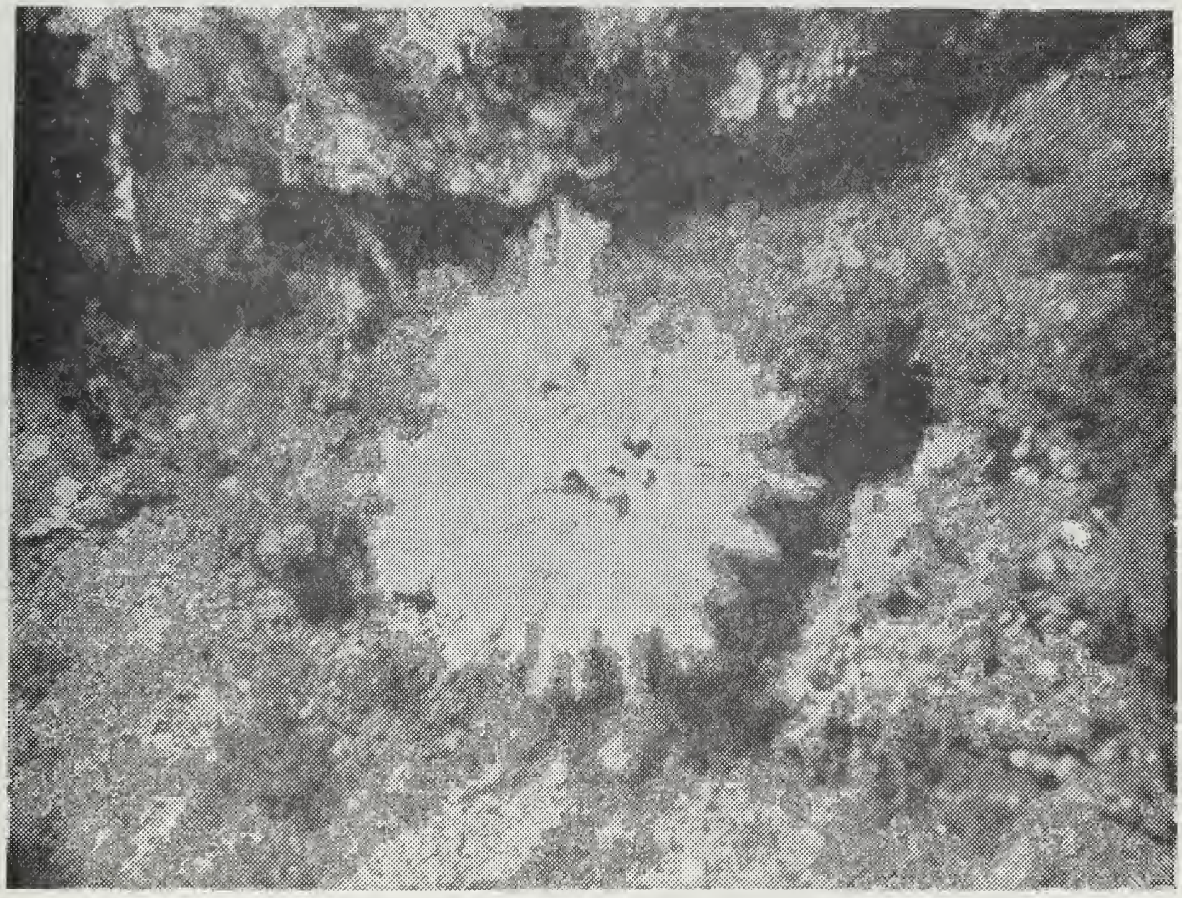


Figure 76, Eudistylia polymorpha

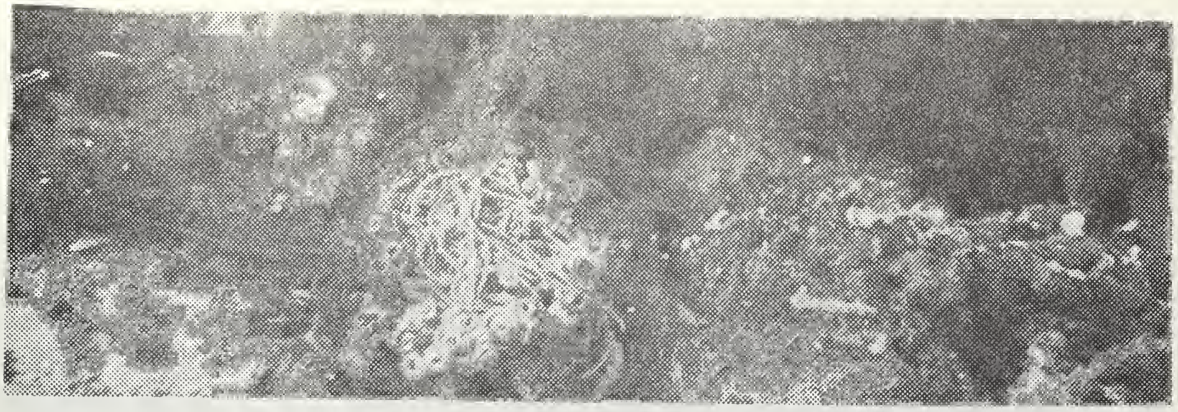


Figure 77. Tentacles of cirriformia sp. (x 1.3)

Figure 78. Loxorhynchus crispatus

Figure 79. Siphons of Chaceia ovoidea. Anemonies are Metridium exilis. Barnacles are Balanus crenatus. This was taken on the vertical ledge in D2.

Figure 80. Siphons of *Chaceia ovoidea*. Crab is the umbrella crab *Cryptolithodes sitchensis*. Algae is *Bossiella orbigniana*.

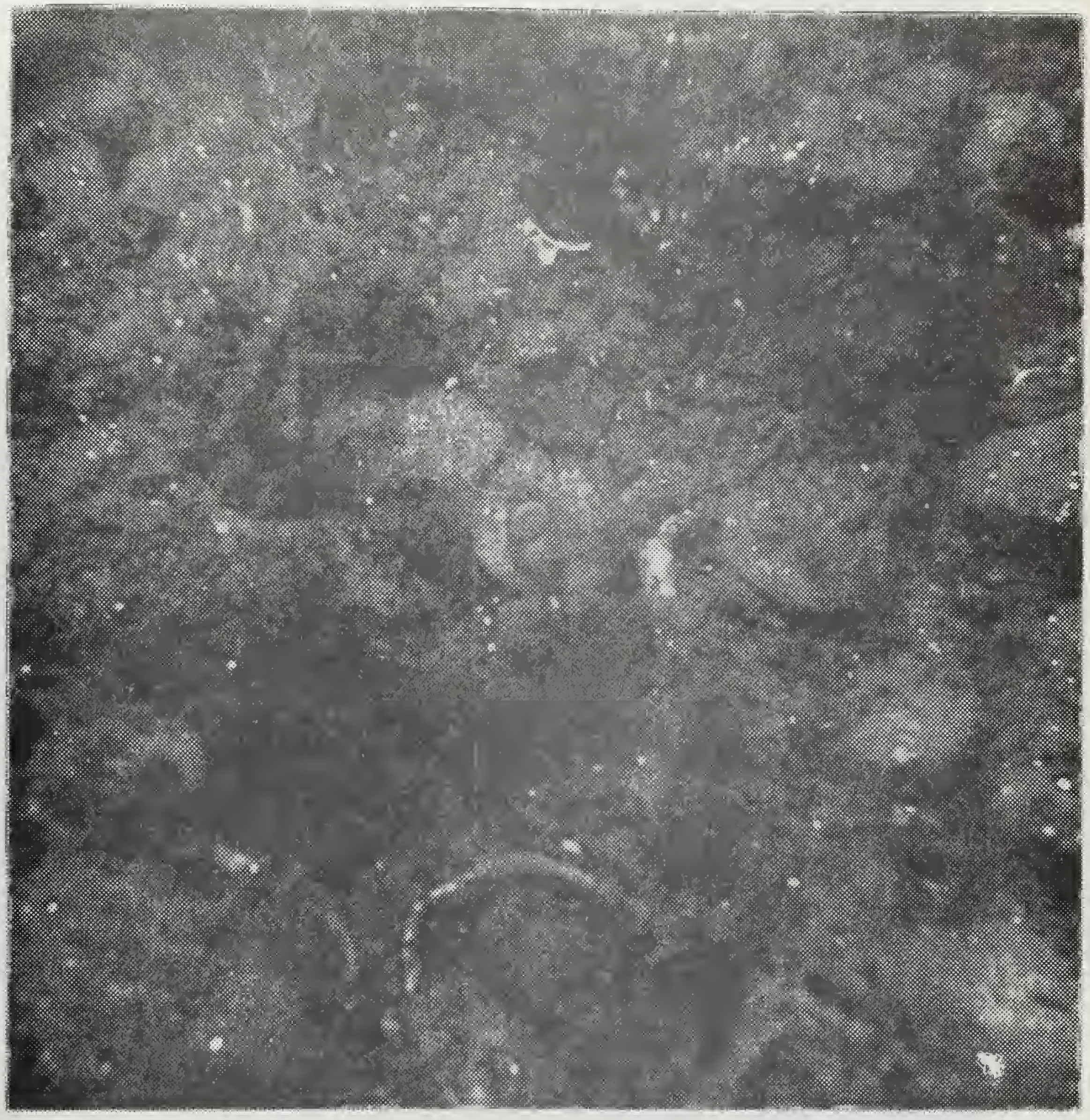


Figure 81. Siphons of Parapholas californica. Note also the burrowing anemone Edwardsiella californica.

Figure 82. Siphons of <u>Parapholas californica</u> (x 6). Tentacles are those of <u>Cirriformia</u> sp.

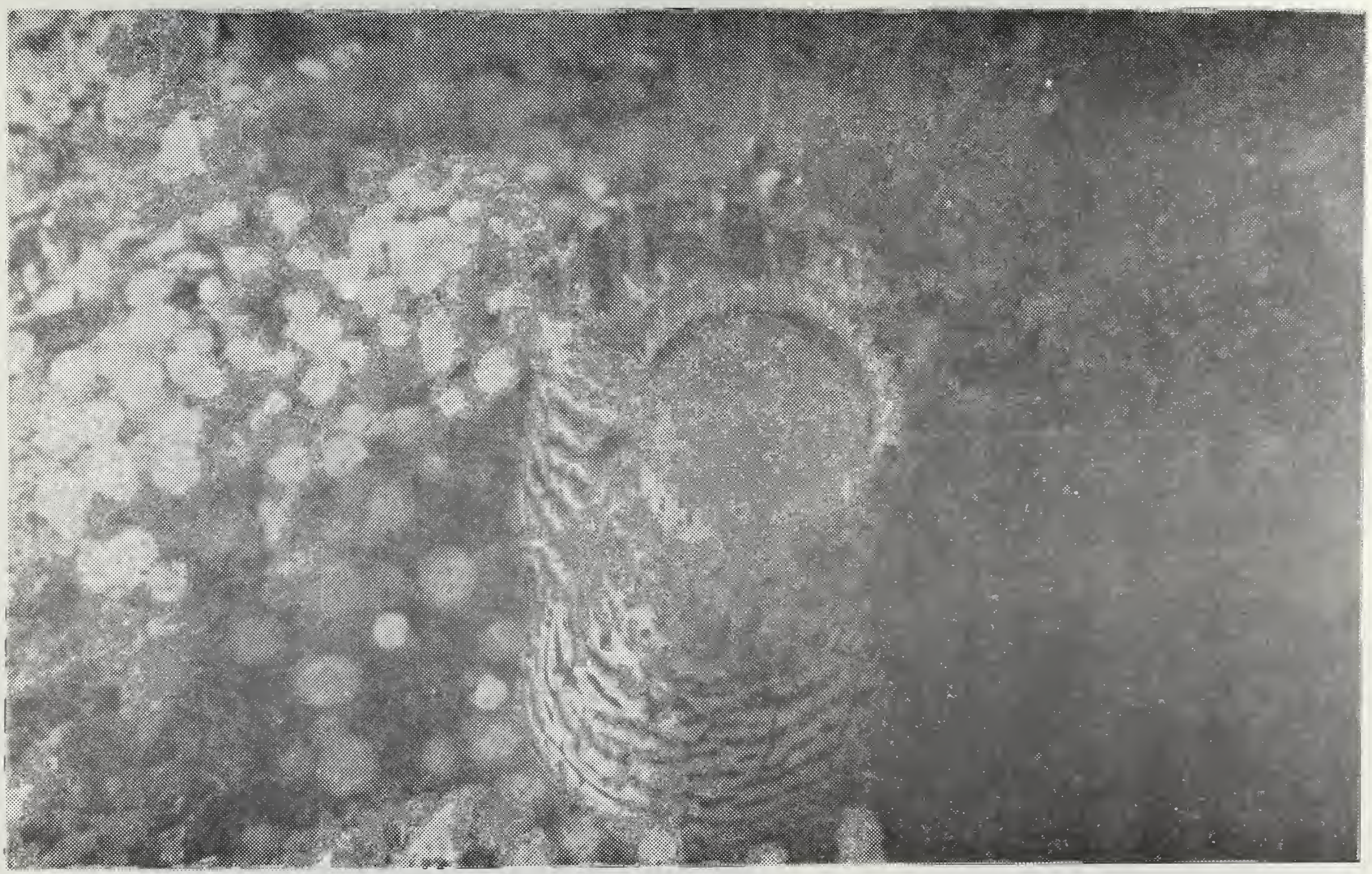


Figure 83. Siphons of <u>Penitella gabbi</u> (x 6). Unidentified sponge P sp.#3 on left.

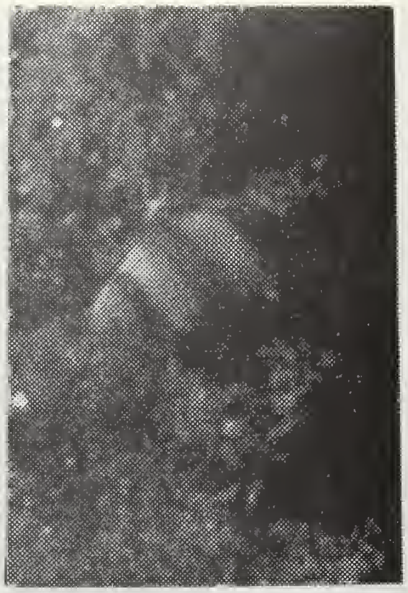


Figure 84. Siphons of Penitella gabbi

Figure 85. Acteon Punctocoelata

Figure 86. Dendronotus albus (x 3)

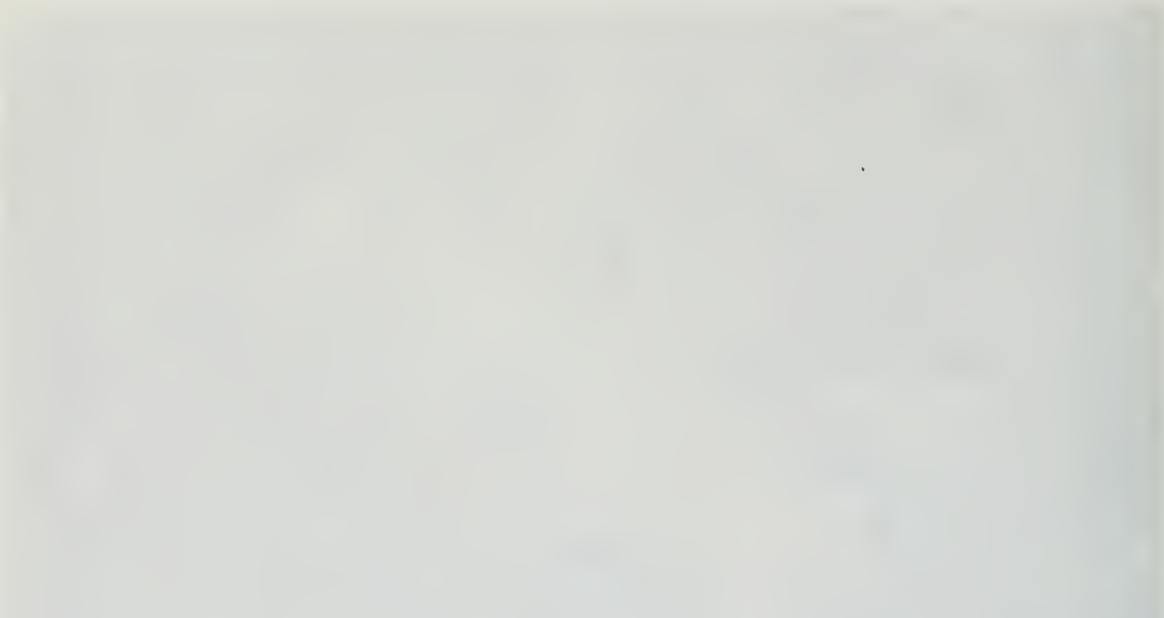


Figure 87. Membranipora membranacea on Macrocystis pyrifera

Figure 88. Thalamoporella californica

Figure 89. Solitary ascidian on right is the rare Cnemidocarpa finmarkiensis. Compound form on left and above is Amaroncium solidum.

Figure 90. Eudistoma molle. Hydroid upper left is Abietinaria spp.

Figure 91. Colony of Pycnoclavella stanleyi (x 2)

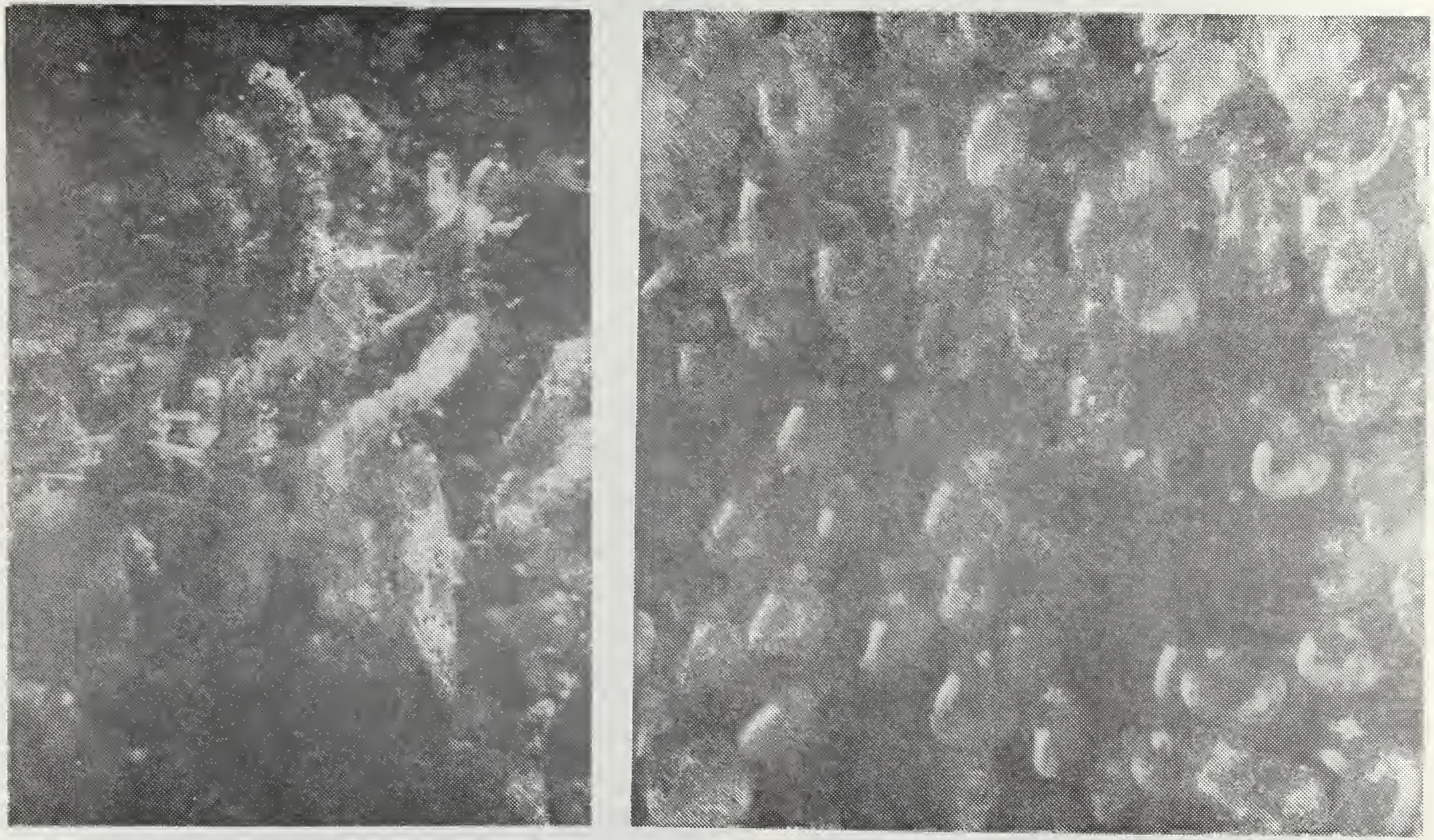


Figure 92. Pycnoclavella stanley. Left photograph (x 4) shows sandy tubes. Photograph on right x 6.

Figure 93. Pyura haustor with apertures extended (x 4)

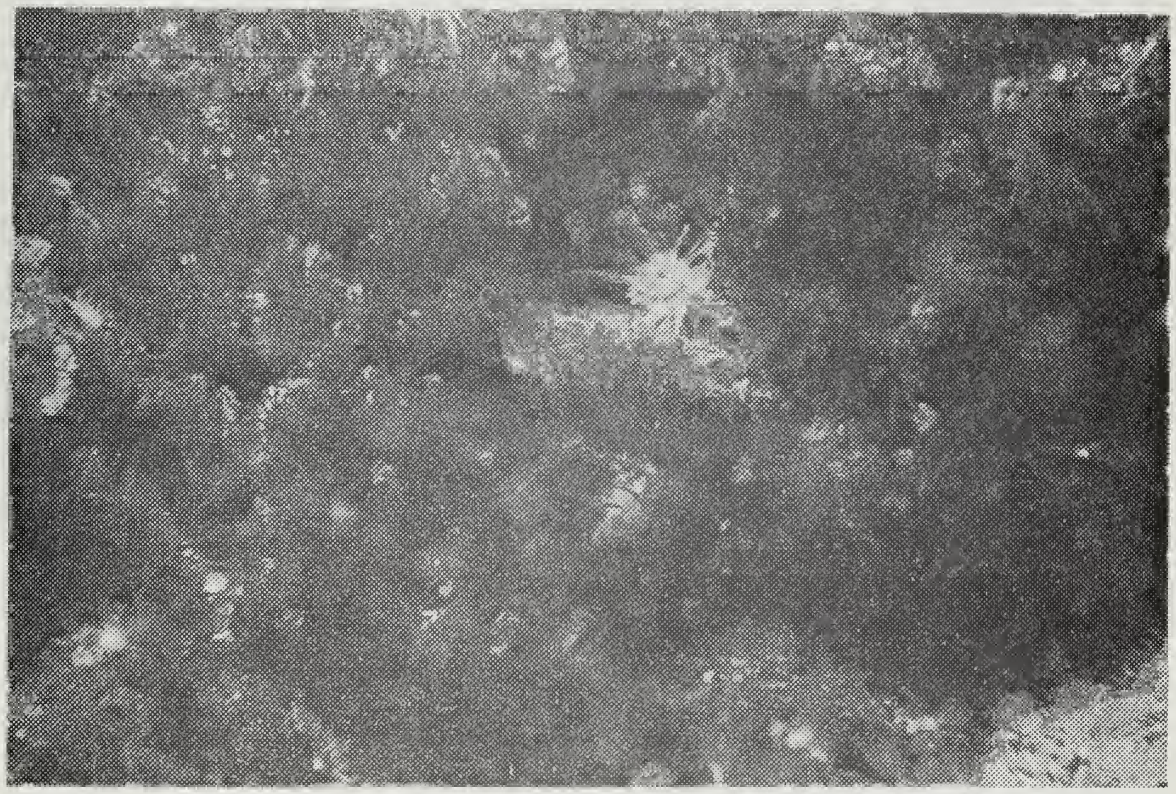


Figure 94. Stylea gibbsii with apertures open (x 4). Anemone is Metridium exilis; Dark tentacles are Dodecaceria fistulicola.

Figure 95. Large colony of Trididemnum opacum. Translucent form at top is Eudistoma diaphanes.

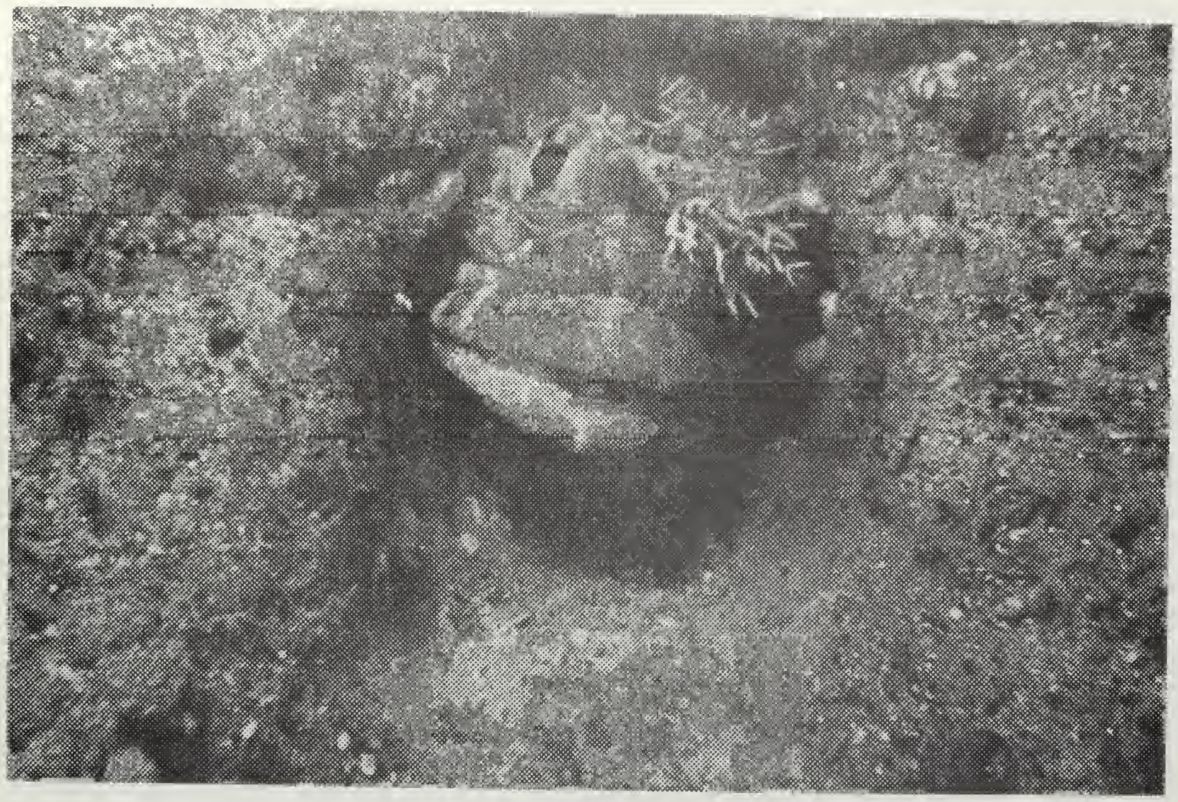


Figure 96. Neoclinus uninotatus

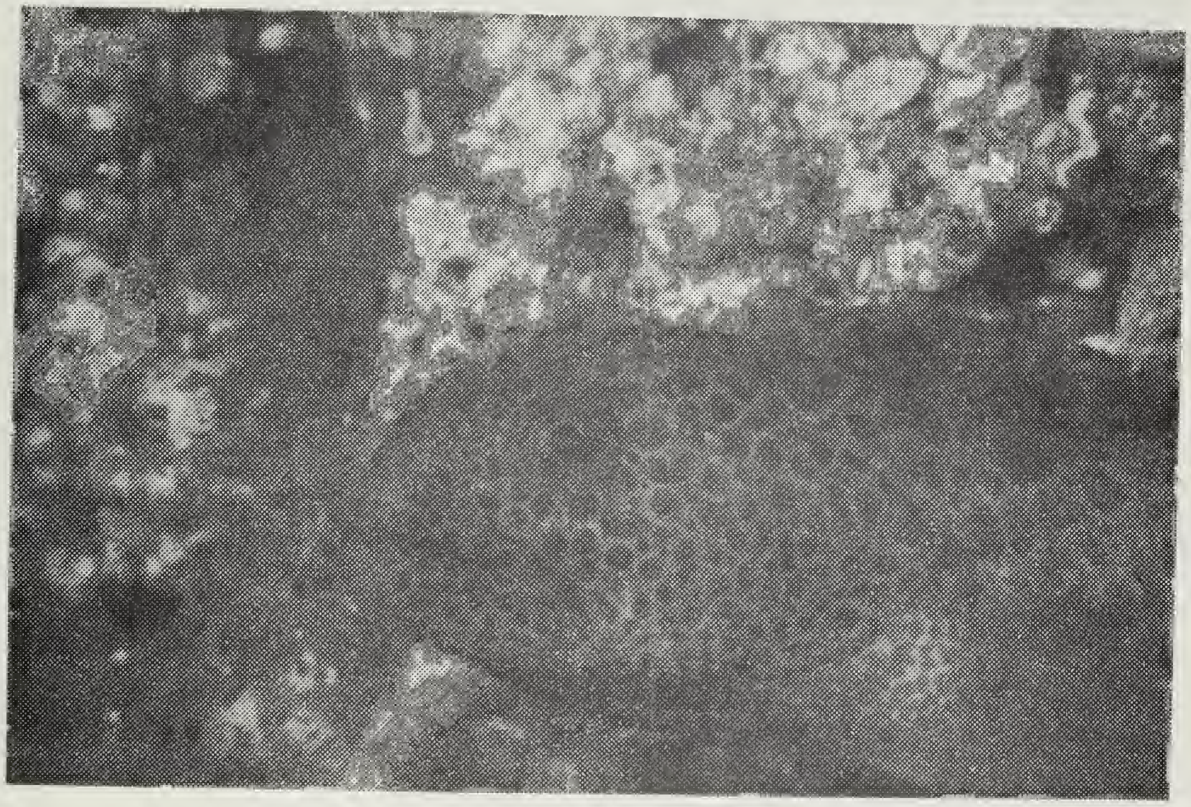


Figure 97. Young wolf eel Anarrhichthys ocellatus

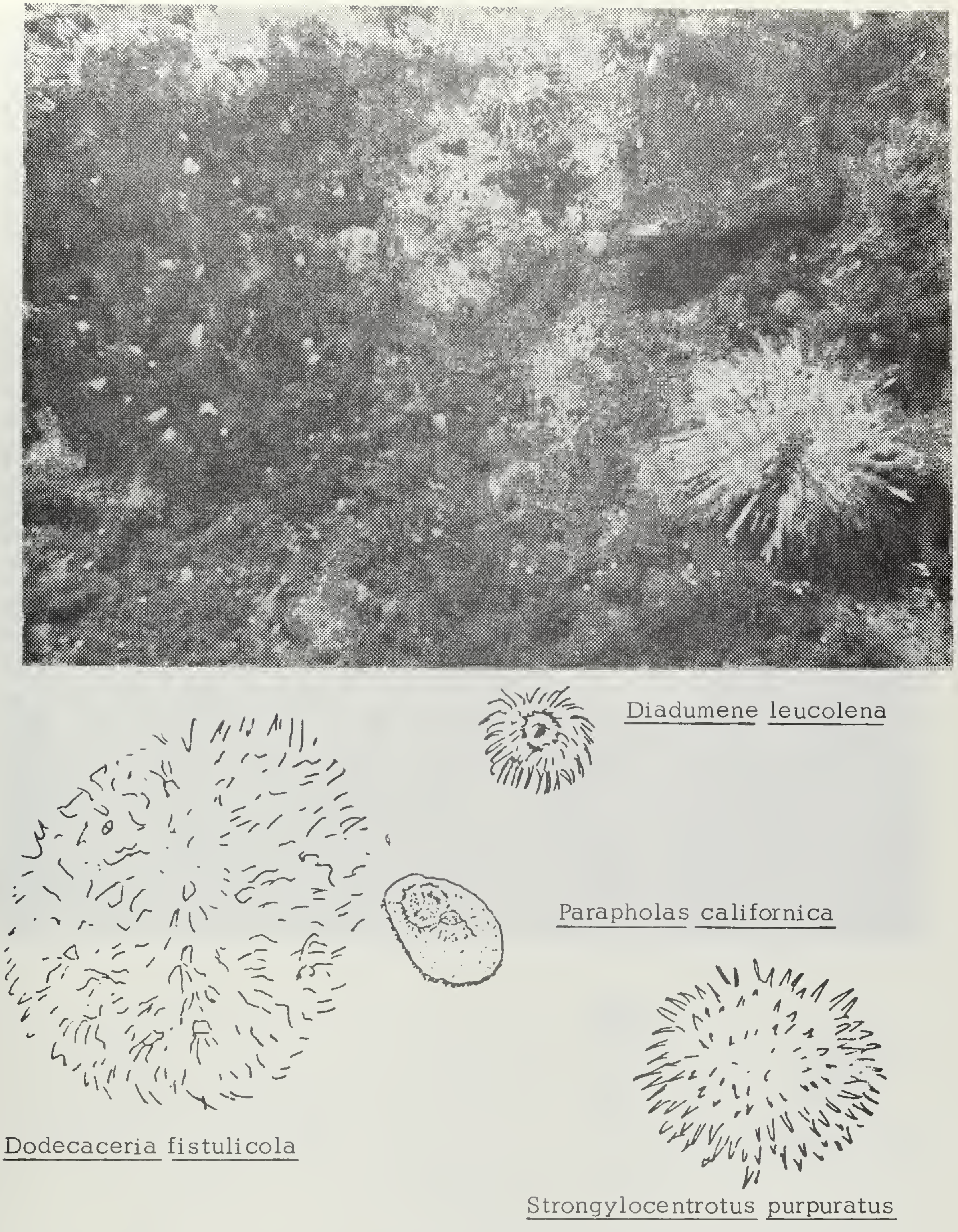
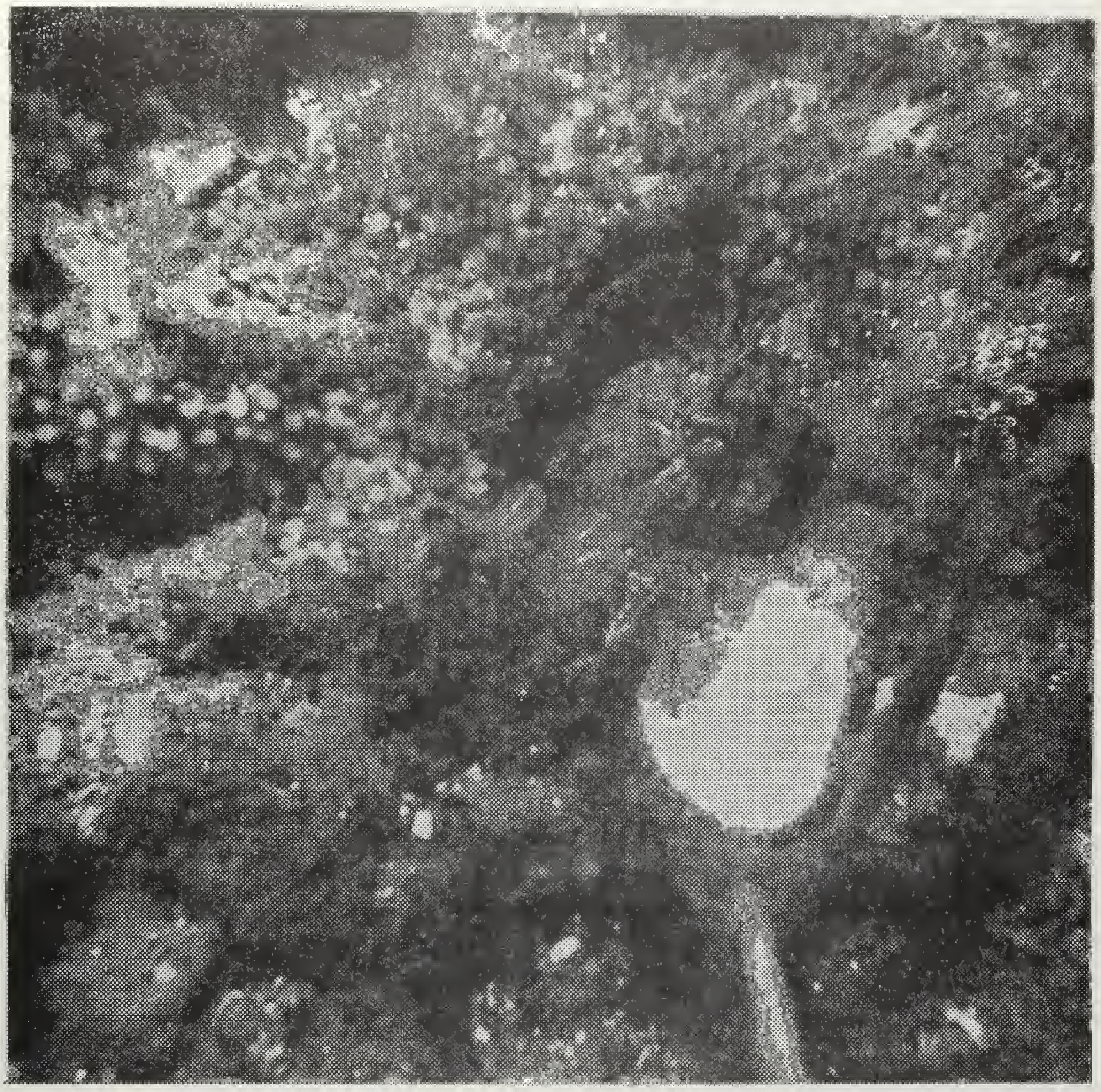

Diadumene leucolena
Parapholas californica
Dodecaceria fistulicola
Strongylocentrotus purpuratus

Figure 98.



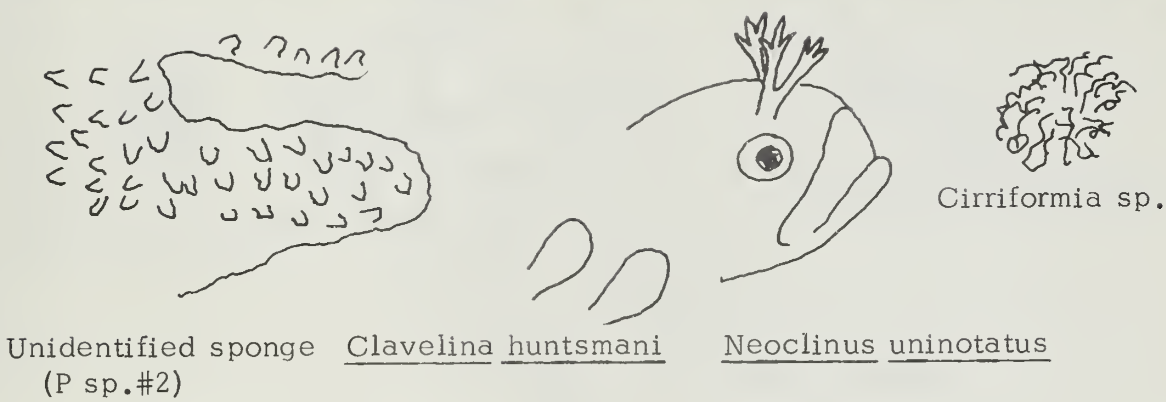

Cirriformia sp.
Unidentified sponge
(P sp.#2)
Clavelina huntsmani
Neoclinus uninotatus

Figure 99.

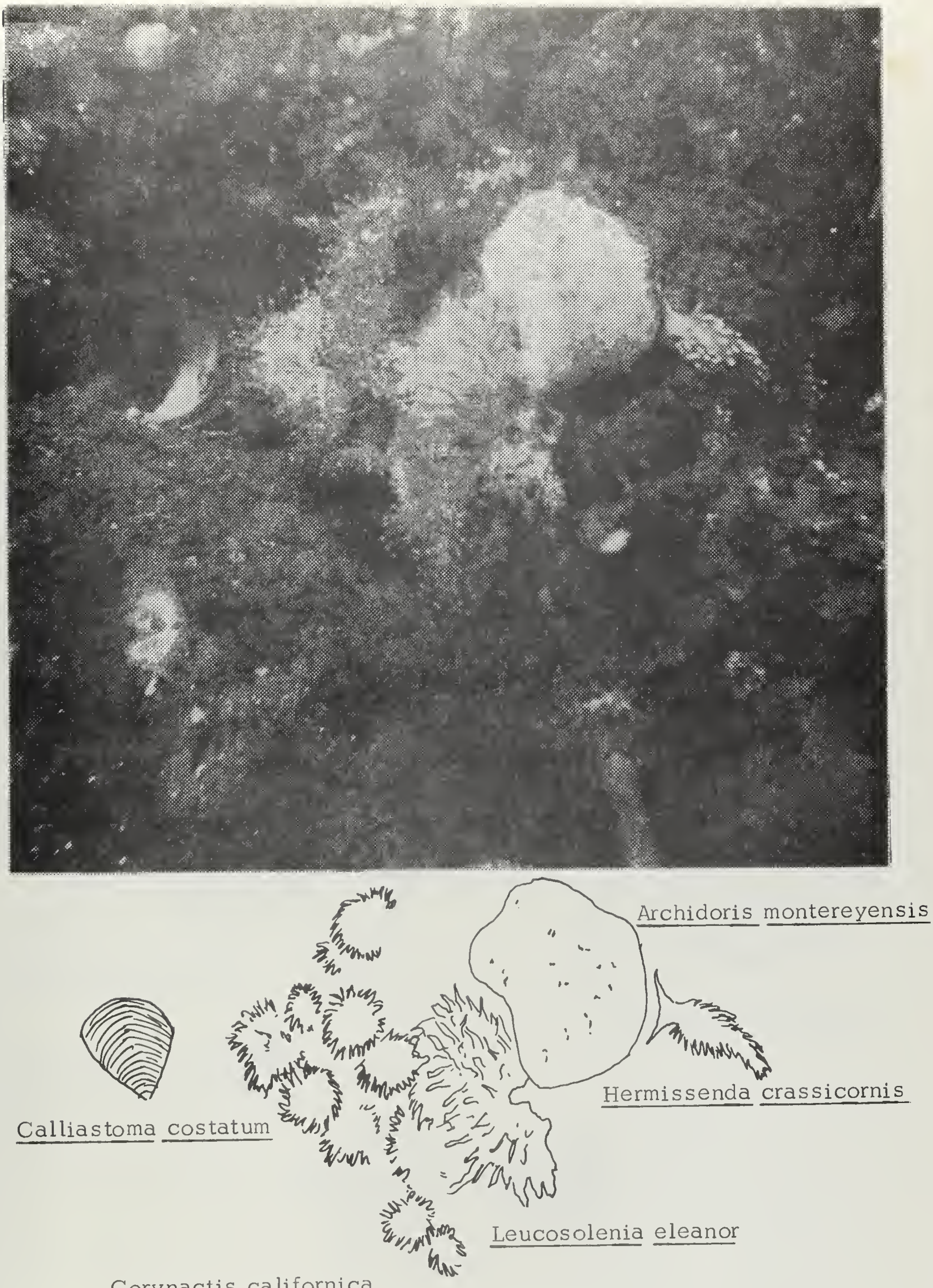

Archidoris montereyensis
Calliastoma costatum
Hermissenda crassicornis
Leucosolenia eleanor
Corynactis californica

Figure 100.

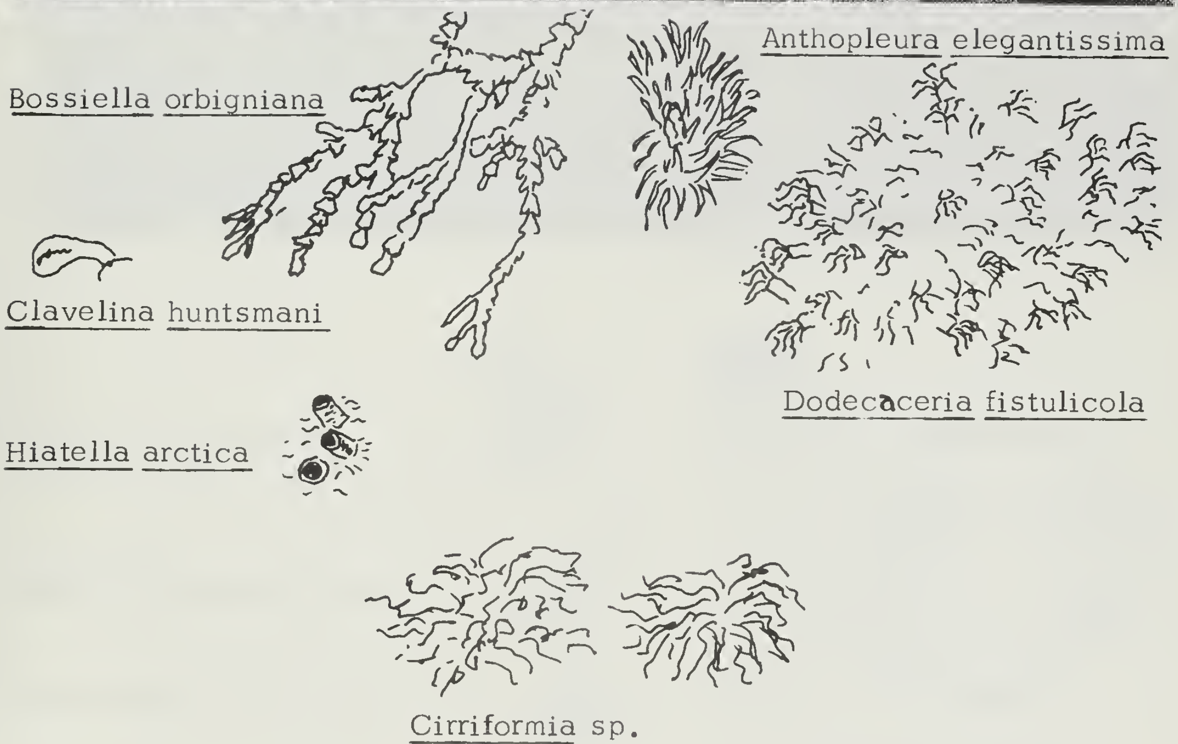

Anthopleura elegantissima
Bossiella orbigniana
Clavelina huntsmani
Dodecaceria fistulicola
Hiatella arctica
Cirriformia sp.

Figure 101.

Bossiella orbigniana
Edwardsiella californica
Eupentacta quinquesemita
Edwardsiella californica
Mimulus foliatus

Figure 102.

APPENDIX E: LIST OF MACROSCOPIC SPECIES OBSERVABLE IN SITU IN THE DEL MONTE BEACH KELP BEDS

Scientific Name	Scientific Name
PORIFERA (Sponges):	_Salmacina_ sp.
Acarnus erithacus	_Serpula vermicularis_
Craniella sp.	_Spirorbis_ sp.
Hymenamphiastra cyanocrypta	_Thelepus_ sp.
Leuconia heathi	Unidentified (Believed to be _Myxicola_ sp.)
Leucosolenia eleanor	SIPUNCULOIDEA:
Polymastia pachymastia	_Dendrostomum dyscritum_
Rhabdodermella nuttingi	_Dendrostomum pyroides_
Unidentified species (6)	_Phascolosoma agassizzi_
COELENTERATA:	ARTHROPODA:
Hydrozoa (hydroids):	Crustacea:
Abietinaria spp.	_Balanus crenatus_
Aglaophenia spp.	_Balanus nubilis_
Plumularia spp.	Isopoda:
Anthozoa (anemonies):	_Idothea resecata_
Anthopleura artemisia	Decapoda (crabs, etc):
Anthopleura elegantissima	_Cancer antennarius_
Balanophyllia elegans	_Cancer gracilis_
Cerianthus sp.	_Cancer productus_
Corynactis californica	_Cryptolithodes sitchensis_
Diadumene leucolena	_Holopagurus pilosus_
Edwardsiella californica	_Lophopanopeus_ sp.
Metridium exilis	_Loxorhynchus crispatus_
Tealia coriacea	_Loxorhynchus grandis_
Tealia crassicornis	_Mimulus foliatus_
Tealia lofotensis	_Pagurus samuelis_
NEMERTEA (nemertean worms):	_Pugettia gracilis_
Cerebratulus californiensis	_Pugettia producta_
Tubulanus sexlineatus	_Pugettia richii_
ANNELIDA:	MOLLUSCA:
Cirriformia sp.	Amphineura (chitons):
Diopatra ornata	_Cryptochiton stelleri_
Dodecaceria fistulicola	_Mopalia ciliata_
Eudistylia polymorpha	_Mopalia muscosa_
Phyllochaetopterus prolifica	_Placiphorella velata_
Sabella crassicornis	_Tonicella lineata_
Sabellaria cementarium	

Scientific Name
Pelecypoda:
Chaceia ovoidea
Hiatella arctica
Hinnites multirugosus
Kellia laperousii
Lithophaga plumula
Parapholas californica
Penitella penita
Penitella gabbi
Pododesmus cepio
Sphenia pholadidea
Zirfaea pilsbryi
Gastropoda:
Prosobranchia (snails):
Astraea gibberosa
Calliostoma annulatum
Calliostoma canaliculatum
Calliostoma costatum
Ceratostoma foliatum
Crepidula adunca
Diodora aspera
Magatebennus bimaculatus
Ocenebra spp.
Pusula californiana
Tegula brunnea
Tegula montereyi
Opisthobranchia:
Tectibranchia:
Acteon punctocoelata
Pleurobranchaea californica
Nudibranchia:
Aegires albopunctatus
Aeolidia papillosa
Ancula pacifica
Anisodoris nobilis
Archidoris montereyensis
Chioraera (_Melibe_) _leonina_
Dendronotus albus
Diaulula sandiegensis
Doriopsilla albopunctata
Flabellina iodinea
Hermissenda crassicornis
Laila cockerelli
Polycera atra
Polycera quadrilineata
Rostanga pulchra

Scientific Name
BRYOZOA:
Membranipora membranacea
Phidolopora pacifica
Thalamoporella californica
ENTOPROCTA:
Barentsia gracilis
ECHINODERMATA:
Asteriodea (seastars):
Dermasterias imbricata
Evasterias troschelii
Henricia leviuscula
Leptasterias sp.
Patiria miniata
Pisaster brevispinus
Pisaster giganteus
Pycnopodia helianthoides
Echinoidea (urchins):
Strongylocentrotus pupuratus
Holothuroidea (sea cucumbers):
Cucumaria miniata
Cucumaria piperata
Eupentacta quinquesemita
Stichopus californicus
CHORDATA:
Ascidiacea (tunicates):
Amaroucium sp.
Boltenia villosa
Clavelina huntsmani
Cnemidocarpa finmarkiensis
Cystodytes sp.
Family Didemnidae
Eudistoma sp.
Eudistoma diaphanes
Eudistoma molle
Euherdmania claviformis
Pycnolclavella stanleyi
Pyura haustor
Styela gibbsii
Styela montereyensis
Synoicum parfustis
Trididemnum opacum
Unidentified species (1)
Vertebrata (fishes):
Anarrichthys ocellatus

Scientific Name
Citharichthys sordidus
Damalichthys vacca
Heterostichus rostratus
Hexagrammos decagrammus
Hypsurus cargi
Neoclinus uninotatus
Ophiodon elongatus
Paralabrax clatharatus
Pheuronichthys decurrens
Porichthys notatus
Sebastodes chrysomelas
ALGAE:
Rhodophyta:
Bossiella sp.
Bossiella orbigniana
Calliarthron sp.
Callophyllis flabellulata
Corallina chilensis
Peyssonnelia pacifica
Plocamium coccineum
Lithothamnion sp.
Lithothrix aspergillum
Phaeophyta:
Cystoseira osmundacea
Desmarestia herbacea
Dictyoneuropsis reticulata
Macrocystis pyrifera
Pterygophora californica

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13. ABSTRACT

Macroscopic organisms collected by SCUBA divers throughout a large portion of the kelp beds at Del Monte Beach, Monterey, California, were identified and a list of species present was compiled. More than 160 such species were found to exist. Collection methods and techniques utilized by divers were documented. Numerous underwater photographs were taken.

A population census and mapping survey was made by divers of the benthic flora and fauna existing within two permanently marked bottom areas, one of which is to be eventually isolated from the open sea by erection of a breakwater. The areas were found to be of generally similar biological population but of markedly different species distribution and relative abundance.

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Population distribution						
Marine ecology						
Monterey Breakwater Study						
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